VOL. 19, NO. 2 June, 1944

THE QUARTERLY REVIEW of BIOLOGY

SEXUAL DIFFERENTIATION IN MOLLUSKS

II. GASTROPODS, AMPHINEURANS, SCAPHOPODS, AND CEPHALOPODS

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(Contribution from the Scripps Institution of Oceanography, New Series, No. 224.)

I. GASTROPODS

IN A preceding review (Coe, 1943) it was mentioned that, among the 10,000 or more species of pelecypod mollusks, there is found every grade of sexual differentiation, from those species that are strictly of separate sexes to others that are functionally hermaphroditic. Furthermore, in certain species the functional sexual phase may change during the individual's lifetime. It was found convenient to classify all these aspects of sexuality into two main groups, namely, (A) ambisexuality (monoecism, hermaphroditism) and (B) unisexuality (dioecism, gonochorism). There are four more or less intergrading categories of ambisexuality: (1) functional ambisexuality (functional hermaphroditism), (2) consecutive sexuality, (3) rhythmical consecutive sexuality and (4) alternotive sexuality. The same categories are found in the gastropods and, indeed, in some other groups of animals and plants.

Of the more than 20,000 species of living gastropods, approximately half are hermaphroditic when fully adult, in contrast with the pelecypods, most of which are of separate sexes (Coe, 1943). Two of the three orders of the class Gastropoda, namely Opisthobranchiata and Pulmonata, are hermaphroditic, with few, if any, exceptions. The third order, Prosobranchiata, contains representatives of all of the five categories of sexuality. In this order the type of sexuality is not in all cases characteristic of the family or even of the genus, for two species of the same genus may differ in their sexual conditions.

Most of the gastropods are provided with a copulatory organ, or phallus, in the male sex, in the male phase, or in the hermaphroditic condition, as the case may be, whereby the sexes or the sexual phases can be distinguished externally (Figs. 1, 3, 4, 5). There are also some examples of sexual dimorphism in shape of shell. Moreover, some of the dioecious species are characterized by differences in rate of growth and longevity of the two sexes. Males, in such cases, grow more slowly and die at an earlier age than females in the same population. Consequently the sex ratios in a group of small individuals will differ widely from a group consisting of an equal number of large individuals. The group of small ones, if they are also young, will consist of equal numbers of males and females, while a group of the largest and oldest individuals will contain only the longer surviving females (Pelseneer, 1935; Van Cleave and Chambers, 1935; Gallien and de Larambergue, 1938).

In a few families, including both unisexual and ambisexual species, the phallus is absent and the reproductive cells of both sexes are discharged into the water, as is usually the case in the pelecypods.

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Ovoviviparity. In numerous species of prosobranchs and pulmonates and in a few opisthobranchs the eggs are fertilized and undergo development to the adult form in the uterine portion of the oviduct. This may occur either in ambisexual or unisexual species. In some species certain individuals may be oviparous while others of the same species, but in a different locality, may be ovoviviparous.

Parthenogenesis. This has been conclusively demonstrated in two species of pectinibranch prosobranchs. In these species, *Hydrobia* (*Paludestrina*) *jenkinsi* and *Campeloma rufum*, males are unknown, and the hereditary line is evidently continued by females exclusively (Mattox, 1937, 1938). Other examples have been reported but without satisfactory proof; most of them are evidently cases of self-fertilization and not parthenogenesis.

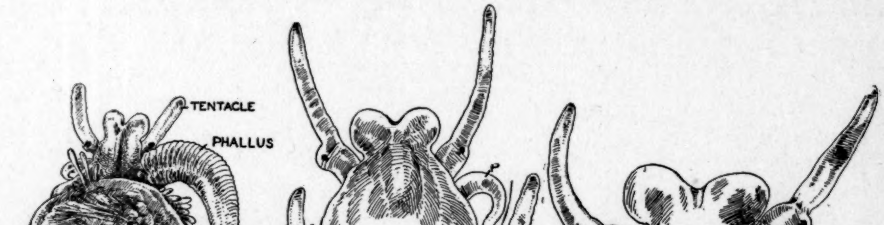

FIG. 1. CONSECUTIVE SEXUALITY IN CREPIDULA PLANA

A, dorsal surface of individual in male phase after removal from shell, showing the relatively large size of the fully developed phallus. B, C, D, outlines of anterior portions of bodies during sexual transformation and in female phase, showing regression of phallus (*p*). All figures drawn at the same magnification.

Neoteny. As occurs also in other groups of both animals and plants, the sexual conditions in the gastropods are sometimes complicated by precocious sexual maturity. This may lead to the production of sexual cells when the individuals are very young, sometimes before the larval development has been completed. This primary sexual phase is often more or less aborted and may be of a different type of sexuality than that in which the individual will function as an adult. In most cases of neoteny a brief male phase precedes a later hermaphroditic condition.

A. AMBISEXUALITY; MONOECISM; HERMAPHRODITISM

In addition to all species of opisthobranchs and pulmonates, numerous examples of this type of sexuality have been reported among the 12,000 or more species of prosobranchs. They include species of *Acmaea*, *Angustispira*, *Bathysciadium*, *Calyptraea*, *Capulus*, *Crepidula*, *Crucibulum*, *Cocculina*, *Enteroxenos*, *Entocolax*, *Entoconcha*, *Entosiphon*, *Janthina*, *Marsenina*, *Odostomia*, *Onchidiopsis*, *Patella*, *Puncturella*, *Stilifer*, *Valvata* and *Velutina*. The sexuality of some of these, as will be explained in the following sections, is more strictly of the consecutive type, the rhythmical consecutive type, or the alternative type. The life histories of many others are not sufficiently known to permit a definite classification. As in so many other groups of animals, ambisexuality is commonly associated with parasitism.

1. *Functional hermaphroditism; Functional ambisexuality*

In this aspect of sexuality there is no incompatibility between male and female characteristics, and each normal individual is provided with a complete set of organs of both sexual types. The gonad produces both sperm and ova, and the genital ducts are often differentiated into male and female portions. The male accessory organs usually, but not invariably, consist of sperm duct, with seminal vesicles for the storage of sperm, accessory secretory glands and eversible phallus. The female accessory organs are usually differentiated into oviduct, uterus, seminal receptacles, and vagina, in addition to accessory glands associated with copulation and with the secretion of yolk and egg shells or capsules.

In most species with this type of sexuality, all mature individuals experience the mating instincts of both sexes and during copulation the sperm is transferred reciprocally, either simultaneously or alternately, to both members of the mating pair. Cross fertilization is thereby generally assured. In some of the pulmonates, however, the gonad produces ripe eggs and sperm simultaneously, and such individuals may reproduce by self-fertilization, generation after generation, when experimentally isolated (Crabb, 1927; Pelseneer, 1935; Ikeda, 1937; de Larambergue, 1939).

Colton and Pennypacker (1938) have followed such an isolated, self-fertilized line through 93 generations, extending over twenty years. The eggs are fertilized within the body, either in the ovary or in the genital duct. Accidental self-fertilization has been reported for other groups of gastropods.

At the end of the reproductive season the phallus may sometimes become atrophied or it may be gnawed off by the individual, to be replaced by regeneration at the beginning of the following mating period.

As a general rule there is a tendency towards protandry. The sperm may be produced in the ambisexual gonad and then discharged before the ova are fully mature, or a definite male phase may precede the hermaphroditic condition. The extent of protandry can sometimes be increased experimentally by an unfavorable environment. This type of sexuality thereby intergrades with rhythmical consecutive sexuality, as is more fully explained in a following section.

2. *Consecutive sexuality*

In this type of sexuality there is but a single change of sexual phase, or sex reversal. Such individuals function as one sex when young and as a different sex when fully adult. Under normal conditions the initial sexual phase is usually male, while the adult phase is either female or hermaphroditic (Figs. 2–5). The two phases may intergrade or they may be sharply separated, as in the pelecypods and many other groups of invertebrates, as well as in some plants and a few fishes.

The histological basis of this type of sexuality depends upon the presence of an essentially ambisexual gonad, associated with an hereditary mechanism which initiates the activity of one of the two types of sexual cells in early life and of the other type after the individual has already functioned in one of the two sexual phases.

Consecutive sexuality is especially characteristic of the family Capulidae (Calyptraeidae), containing 7 genera and about 150 species. The best known examples of these belong to the genera *Calyptraea*, *Crepidula*, and *Crucibulum*. All the species of these genera, of which the life histories are known, function as males when young and later change to the female phase. The female phase continues for the remainder of the individual's life (Figs. 3, 4, 5).

These mollusks lend themselves readily to experimentation, for they are sedentary when adult and thrive in screened boxes immersed in the sea, requiring no special feeding. The successive sexual phases of each individual can be followed by allowing the animal to attach itself to the inner surface of a bottle from which the bottom has been removed.

In some of these species the transformation of the sexual phase is gradual and the individual passes through a series of ambisexual stages. In others the succeeding phases are sharply separated, with a return to a condition of sexual immaturity after the termination of the male phase. The change in sexuality involves not only the gonad but also the genital ducts and copulatory organs, as well as the associated behavioristic instincts.

In the Capulidae all normal individuals reach the functional male phase when they are very young and when they are only a small fraction of their definitive size (Figs. 1–5). They are then motile. In most species, each young snail tends to creep about until it finds an individual of the same species in the female phase, whereupon it attaches itself to the dorsal side of the female's shell in a position adjacent to the female copulatory organ (Figs. 3, 8). Here it may remain for several months or until ready to transform to the female phase and, in some species, even after reaching the female phase. Not infrequently two or more male-phase individuals attach themselves, temporarily or permanently, to the shell of a single female. In other species the males usually occupy positions in the vicinity of the female and move to the mating position at night (Coe, 1938b).

male phase the residual spermatogenic cells in the gonad become cytolyzed and absorbed, together with such sperm as may remain in the seminal vesicles. Later the seminal vesicles are gradually transformed into a portion of the future oviduct. The phallus then atrophies, leaving only a small rudiment which may completely disappear in the female phase (Figs. 1, 2, 4, 5, 6).

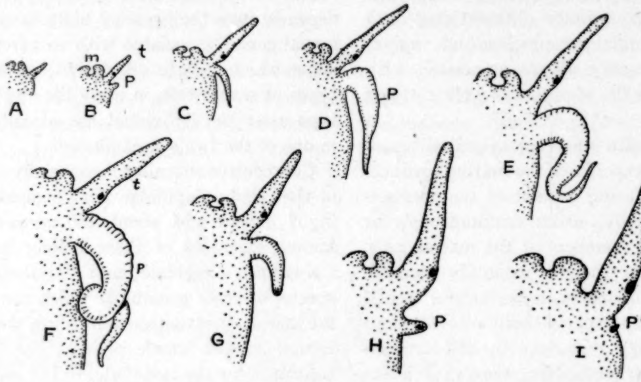

FIG. 2. CONSECUTIVE SEXUALITY IN CRUCIBULUM SPINOSUM, SHOWING SUCCESSIVE STAGES IN THE DEVELOPMENT AND ABSORPTION OF PHALLUS

A, sexually immature. B, C, D, early male phases with spermatogenesis in progress. E, F. functional male phases. G, H, stages in transition to female phase. I, female phase, with rudiment of former phallus; *m*, mouth; *p*, phallus; *t*, tentacle, with ocellus.

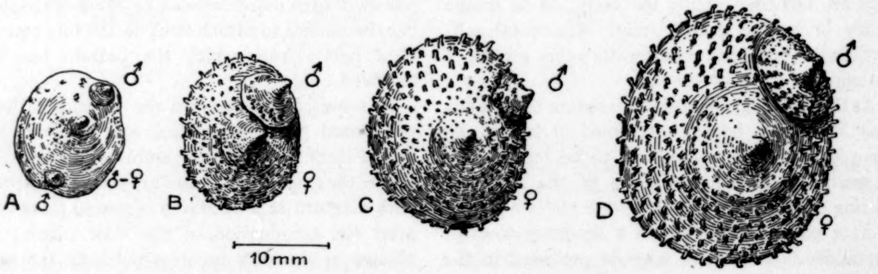

FIG. 3. CONSECUTIVE SEXUALITY IN CRUCIBULUM SPINOSUM

A, shell of individual in process of transformation from male to female phase, with two immature male-phase individuals on surface. B, C. younger and older female-phase individuals with males in mating position. D, old female, near end of life, with mated male-phase individual nearly ready to transform to female phase.

Male phase. Soon after hatching from the egg, and in one species even before hatching (Moritz, 1939), a slender copulatory organ, the phallus, grows out from the body behind the right tentacle (Figs. 1, 2, 5). During copulation the phallus transfers the sperm from the seminal vesicles of the male to the female's vagina, whence they reach the uterus and the seminal receptacles (Figs. 4, 6).

Transition phase. After the completion of the

During the period of sexual transformation, the ovogonia and young ovocytes, which have remained on the wall of the gonad while spermatogenesis was in progress, resume activity. In species in which there is a sharp demarcation between male and female phases, as shown in Fig. 7, the discharge of the sperm and the subsequent cytolysis of the residual cells leave only a few ovogonia and scattered ovocytes along the walls of the gonadal follicles (Fig. 7). The individual has thus returned to a state of sexual immaturity.

Female phase. At the beginning of the female phase the ovogonia multiply rapidly, and the ovocytes increase in size to such an extent that the resulting ovary is many times larger than the spermary which it has supplanted (Fig. 7, C′). The genital duct is then reconstructed into oviduct, uterus with fertilization chamber and seminal receptacles, and vagina (Figs. 4–6). In the meantime the individual may have grown to several times the size it had attained while the male phase was in progress.

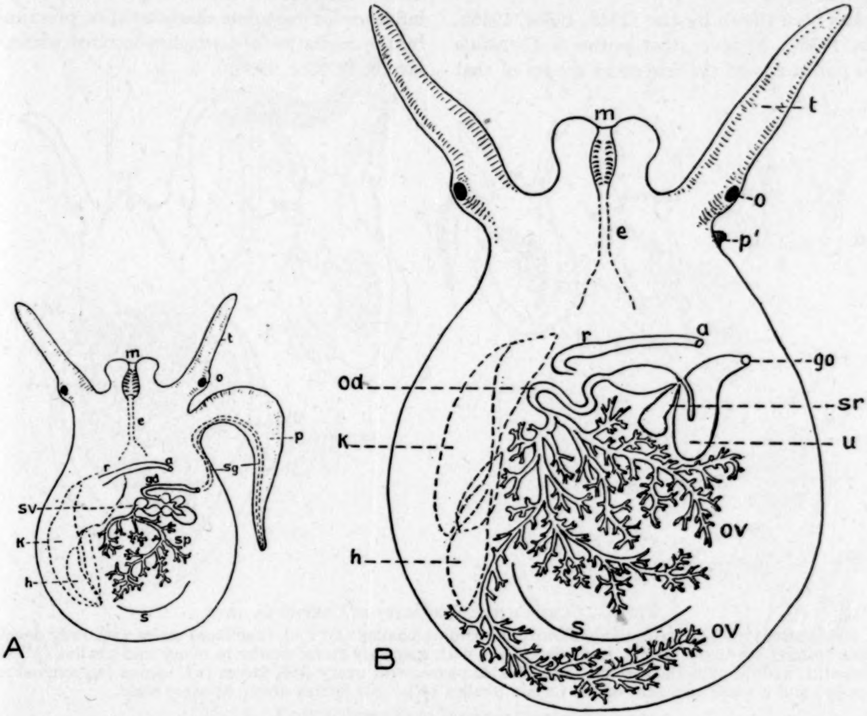

FIG. 4. CONSECUTIVE SEXUALITY IN CRUCIBULUM SPINOSUM

Diagrams of reproductive organs in male and female phases, drawn at the same scale of magnification. A, male phase, showing branching spermatic follicles (*sp*), seminal vesicles (*sv*), seminal groove (*sg*) and phallus (*p*); other letters indicate: *a*, anus; *e*, esophagus; *h*, heart; *k*, kidney; *m*, mouth; *o*, ocellus; *s*, internal shell; *t*, tentacle. B, female phase, with ovary (*ov*), oviduct (*od*), uterus (*u*), genital opening (*go*), seminal receptacle (*sr*) and rudiment of former phallus (*p′*); other letters as in A.

Associated with the change in sexuality is a marked alteration in behavior, whereby the individual, which was so characteristically masculine when young, now becomes strictly sedentary; she receives her mate, lays her eggs in capsules beneath her foot, and protects her young until they are prepared for their own independence.

Although all normal individuals pass through this sequence of sexual phases, the extent of each phase may be profoundly modified by environmental conditions such as unfavorable temperature lack of suitable food, parasitism, accumulation of wastes or other deleterious substances in the water, and especially by association with other individuals of the same species.

This influence of association has been observed in several different species. Gould (1917a, 1917b, 1919) came to the conclusion that the intimate association of the young individual with another of larger size, but of either sexual phase, was necessary for the realization of the functional male phase in *Crepidula plana.* Young individuals, if isolated, were thought to remain in a neuter condition until their later transformation to females. The male-differentiating stimulus was supposed to be transferred through the water from an older (particularly female-phase) individual to the sexually undifferentiated young. Ishiki (1936, 1939) came to the same conclusion in regard to two other species of the genus.

It has been shown by Coe (1935, 1936a, 1936b, 1938a, 1938b), however, that neither in *Crepidula plana* nor in any of the five other species of that genus studied is association with other individuals a prerequisite for the development of the functional male phase. Such association, although usual in nature, is not an essential stimulus for maleness. This is true also for *Crucibulum spinosum* (Coe, 1938c).

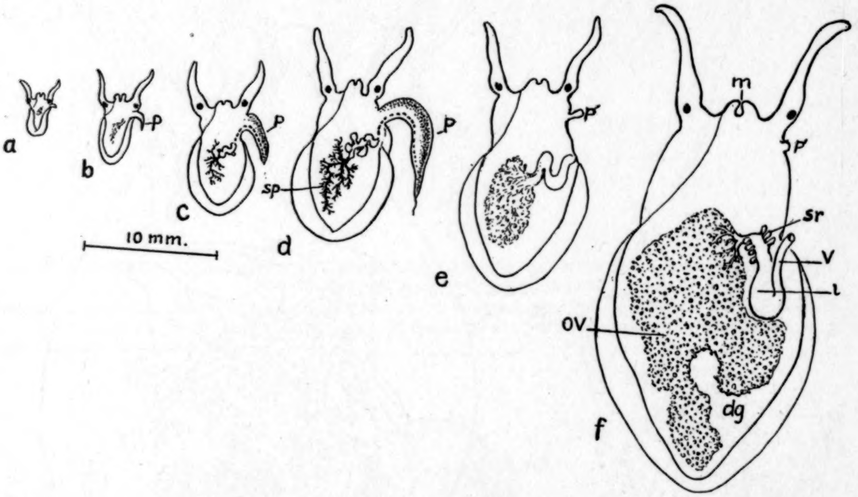

Fig. 5. Consecutive Sexuality in Crepidula onyx

a, b, immature male-phase individuals with developing phallus (*p*); c, d, functional males with fully developed phallus (*p*) and spermary (*sp*); e, transition stage, with spermary transforming to ovary and phallus (*p′*) nearly absorbed; f, mature individual in functional female phase, with ovary (*ov*), uterus (*u*), vagina (*v*), seminal receptacles (*sr*) and a small rudiment of the former phallus (*p′*). All figures drawn at same scale.

Nevertheless, the association of the male-phase individual with one in the female phase, with the accompanying opportunity for copulation, not only prolongs the period which the individual will spend in the male phase but also increases the amount of sperm produced. Isolation of male-phase individuals during the mating period usually leads to the termination of that phase and the inauguration of the female phase.

There seems to be no evidence that the accentuation and prolongation of the male phase by association with the female is due to any masculinizing chemical secretion or hormone which might pass through the water from the body of the female to that of the male, as was formerly assumed. It seems more probable that the stimuli received by the male through his sense organs, during his association with the female, are of such a nature as to influence his masculine characteristics, presumably by the mediation of hormones secreted within his own body (Coe, 1938b).

The sequence of sexual phases in these mollusks is comparable with other types of metamorphosis in animals and is likewise subject to environmental influences. Either the male or the female phase can be accelerated, postponed, or inhibited experimentally, but the sequence cannot be reversed (Coe, 1938a).

It should be mentioned however, that not all the young male-phase individuals react in the same way to the mating stimulus. Some appear to be less masculine than others in their behavior. They leave their mating positions after a few weeks and move to other situations on the female's shell or to neighboring objects. They then begin transformation to the female phase while much younger and smaller than other individuals which, in some species, may retain the mating position for several months or even for more than two years (Coe, 1938b).

It has often been observed that the male phase becomes functional at a smaller size in mated than in solitary individuals. Although it has sometimes been assumed that this is the direct result of mating, it seems more plausible to suppose that those young, which reach the male phase earliest, are the ones that are most likely to be mated earliest, by virtue of the early development of their masculine instincts which lead them to seek the female. Furthermore, the rapid development of the reproductive system tends to retard the growth of the body temporarily. Isolation of mated males is usually followed by rapid growth, the substance of the cytolyzed male gonad, gametes, and phallus being utilized for the nourishment of the somatic tissues of the following female phase. Some of the young, either by chance or by choice, remain solitary throughout the entire male phase. Minor genetic differences may be responsible for variations in the activities of the gonads and, thereby, for differences in behavior under apparently uniform conditions.

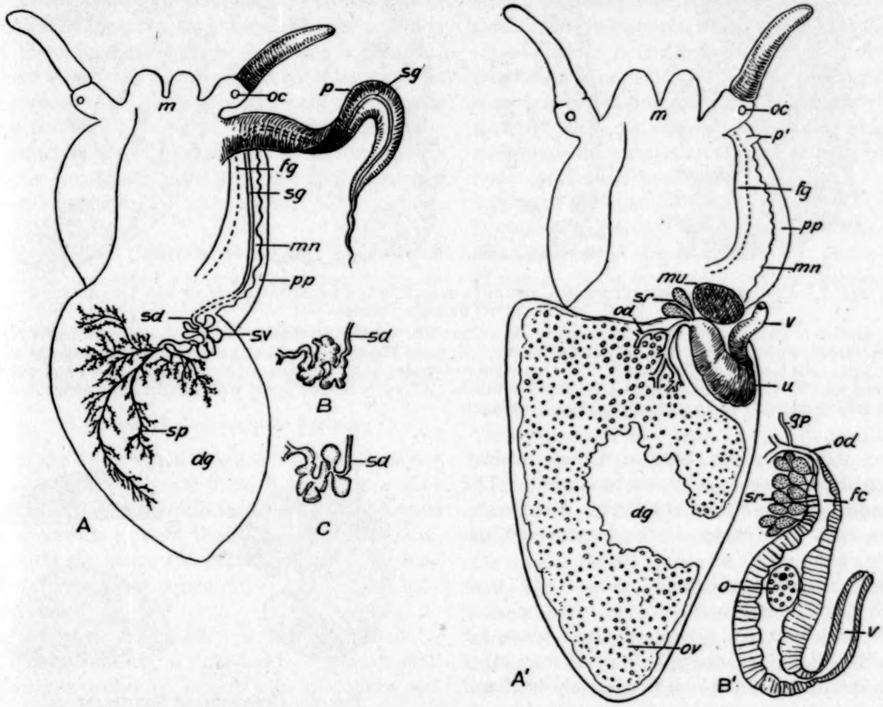

FIG. 6. CONSECUTIVE SEXUALITY IN CREPIDULA ONYX

A, male-phase individual with fully developed phallus (*p*), spermary (*sp*), seminal vesicles (*sv*) and sperm groove (*sg*), the latter leading to end of phallus. B, C, variations in conformation of seminal vesicles and sperm duct (*sd*). A′, individual in female phase, after transformation of the gonad into ovary (*ov*) and the genital duct into oviduct (*od*), uterus (*u*), vagina (*v*) and seminal receptacles (*sr*). B′, optical section of uterus with ovum (*o*), fertilization chamber (*fc*), seminal receptacles (*sr*) and vagina. Other letters indicate: *dg*, digestive gland; *fg*, food groove; *gp*, gonopericardial duct; *m*, mouth; *mn*, mantle; *oc*, ocellus at base of tentacle; *p′*, rudiment of former phallus; *pp*, propodium.

In *Crepidula fornicata* and *C. onyx*, those individuals which live on muddy bottoms, where there are no solid objects to which they can attach themselves, frequently pile up in groups of 6 to 12 or more. These groups continue from year to year, newly arrived young attaching themselves to the top of the group as the old, female-phase individuals die at the bottom (Fig. 8).

When the individuals composing these groups are separated, the oldest females will be observed to have lost the ability to attach themselves to any object and soon perish, because of their inability to feed or as the result of attacks by enemies. The younger individuals tend to collect in new groups, again with the females at the bottom and the young males at the top (Coe, 1938a).

Immature young of both *C. fornicata* and *C. onyx* often attach themselves singly to rocks or other solid objects which allow unlimited space for growth. If they chance to be isolated from other individuals, the male phase is relatively brief and growth continues in the transition stage and female phase to a size much greater than is possible when attached to an object so small as to restrict the growth (Fig. 8). The size and shape of the shells often differ so greatly that the two growth forms were formerly thought to constitute separate species (Coe, 1942b). The arrival of a male-phase individual is necessary in order that fertile eggs may be produced, because the sperm, which were formed when the individual was in the male phase, are all cytolyzed before the female phase becomes functional. After mating, an isolated individual may continue to produce fertile eggs for more than a year.

The ratio of male-phase to female-phase individuals is much larger when the animals are associated in colonies than it is when individuals are isolated, for the reason that the length of time which is spent in the male phase is greater in the former case than in the latter.

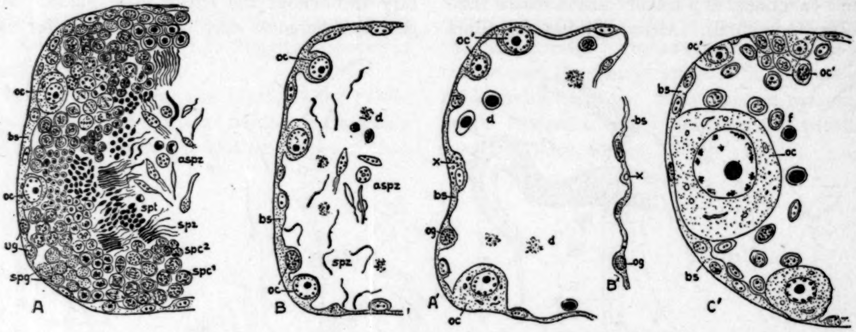

FIG. 7. CONSECUTIVE SEXUALITY IN CREPIDULA FORNICATA; TRANSFORMATION OF THE GONAD FROM MALE TO FEMALE PHASE

A, section of gonad in functional male phase, showing maturation of spermatozoa (*spz*) and atypical spermatosomes (*aspz*), with two ovocytes (*oc*) on periphery. B, early phase in sexual transformation; most of the spermatogenic cells have been discharged. A′, transition to female phase; multiplication of ovogonia (*og*) and growth of ovocytes (*oc*). B′, wall of completely emptied follicle. C′, early female phase with proliferating ovogenic cells (*oc′*), follicle cells (*f*) and one nearly mature ovum (*oc*).

A few representatives of other families have a similar sequence of male and female phases, as Ankel (1930) has demonstrated in *Janthina* and *Scala*.

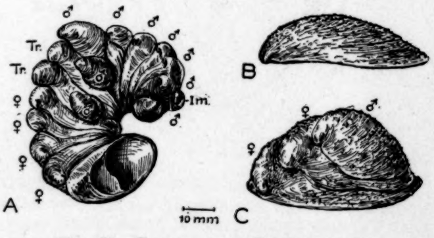

FIG. 8. CONSECUTIVE SEXUALITY IN CREPIDULA ONYX

A, group of 16 individuals living on muddy bottom; at the base are 4 female-phase individuals to which two transition-stage individuals are attached; superimposed on these are nine male-phase individuals and one which is sexually immature. The basal female is attached to a dead shell of the same species. B, isolated individual which had attached to rock; such individuals experience only a brief male phase and reach a much larger size than when they are attached to small objects. C, group of two female-phase individuals and one superimposed male; the basal female had been attached to rock. All drawings at same scale.

Consecutive sexuality is also found in several genera of the suborder Pteropoda, including *Aplysia, Clio, Clione, Cymbelia,* and *Eolis.* The protandric nature of the reproductive system is very definite, the gonads of nearly all young individuals being distinctly of the male type, while the adults function as hermaphroditic females. This type of sexuality has been fully described by Hsaio (1939a, 1939b) for *Limacina retroversa*.

In some species of slugs (family Limacidae) the functionally hermaphroditic condition is likewise preceded by a brief male phase. The sexuality of the gonad appears to be influenced by the nutrition of the animal, for when nourishment is abundant there is a much larger proportion of ovocytes as compared with the spermatogenic cells than under less favorable conditions. Starvation checks the production of ovocytes, and the gonad may appear to be exclusively male after the individual has been kept for two months without food (Richter, 1935).

Rosenwald (1926) also found that *Limax laevis* became protandric or proterogynic according to the environmental conditions, particularly the amount of moisture. The more favorable the conditions were for rapid growth the greater was the proportion of ovocytes in the ambisexual gonad.

3. *Rhythmical consecutive sexuality*

In the discussion of functional hermaphroditism it was mentioned that there is often a tendency for the male and female sexual cells to be formed in succession and not simultaneously. Not infrequently the sperm are discharged from the gonad at each spawning period before the ova are fully mature.

This type of sexuality is well illustrated by *Valvata tricarinata*, as described by Furrow (1935). Here the gonad is divided into medullary and cortical portions, the former producing sperm and the latter ova. The individual is morphologically ambisexual, with highly differentiated accessory reproductive organs of both sexual types. At each reproductive period the sperm mature first. They are then discharged from the gonad and transferred to the seminal receptacle of another individual before ovogenesis is completed. After ovulation the gonad returns to its former ambisexual condition in preparation for another sequence of temporary male and female phases.

4. *Alternative sexuality*

A good example of this type of sexuality is found in the limpet *Patella vulgata*. In this species, as reported by Orton (1919, 1928), 70.8 per cent of the smallest, and evidently youngest, sexually mature individuals in the population studied were found to be functionally male and only 4.4 per cent female. With increase in size and age the proportion of males decreases until the largest, and presumably the oldest, individuals showed a ratio of 34.7 in the male phase to 64.2 in the female phase. Direct proof of change of sexual phase was not obtained but the conditions are closely similar to those in the oviparous oysters, where a change of sexual phase in both directions has been definitely established (Coe, 1938d, 1943). Orton suggested, as has since been proved for the oviparous oysters, that the young population contains two kinds of male-phase individuals, true males and temporary males (protandric females).

Most of the other species of true limpets (group Docoglossa), however, appear to be of separate sexes, although *Acmaea rubella* is ambisexual (Thorson, 1935), and a few other examples of ambisexuality have been reported.

B. UNISEXUALITY; DIOECISM; GONOCHORISM

Except for the numerous cases noted in the preceding sections, all the other species of the order Prosobranchiata have been thought to be of separate sexes. It is not improbable, however, that further study of the life histories of the 12,000 or more species included in the order will yield many additional examples of ambisexuality. In some of the species the males can be distinguished externally not only by the phallus but also by their more slender shells. When fully adult they are commonly smaller than the females of the same age and may have different habits during the reproductive season. In some species they also have shorter lives. For these reasons great inequalities in the sex ratios of small as compared with large individuals in any collection should not be considered as satisfactory evidence of a change in the sexuality of any individual (Van Cleave and Chambers, 1935; Pelseneer, 1935; Gallien and de Larambergue, 1938; Cole, 1942).

In several families of prosobranchs there are neither morphological provisions nor instincts for mating; the phallus is absent and the reproductive cells of both sexes are discharged into the water. The continuation of the species depends upon the maturity of eggs and sperm at the same season of the year and also upon the stimulus which the presence of gametes of one sex provides for the activation of the spawning reaction in individuals of the opposite sex in the vicinity Many of the species belonging to the suborder Scutibranchiata have these characteristics.

II. AMPHINEURANS

Most of the representatives of the class Amphineura are of separate sexes but none of them has any provision for copulation. Both sexes, when subjected to appropriate stimuli, discharge their reproductive cells into the water (Grave, 1922). The production of very numerous minute ova and a tendency of the animals to congregate are the only assurances of fertilization. A large chiton (*Ischnochiton*) may deposit nearly 200,000 eggs at a single ovulation. In a few species spermatozoa from neighboring males may enter the branchial furrow or even the oviduct of the female and fertilize the eggs contained therein.

With the exception of *Trachydermon raymondi*, all the species of true chitons (order Polyplacophora) of which the life histories are known are unisexual. This is likewise true of the Chaetodermorpha of the order Aplacophora. All the other wormlike Aplacophora are ambisexual, and in some of them (*Dondersia* and *Neomenia*) the hermaphroditic condition is preceded by a brief male phase (Pelseneer, 1935).

III. SCAPHOPODS

All the representatives of the class Scaphopoda, so far as known, are of separate sexes and are without provision for internal fertilization. The gametes of both sexes are discharged into the water.

IV. CEPHALOPODS

The Cephalopoda are invariably of separate sexes, with highly specialized organs for copulation. The sperm are packed in capsules which the male transfers to the mantle cavity of the female by means of one of his arms. This arm is specially modified for the purpose, and in *Argonauta* and a few other genera, it is detached from the male's body during copulation and left within the female's mantle cavity. The missing arm is later replaced by regeneration.

CONCLUSIONS

Of the five different types of sexuality found in animals and plants, namely, functional ambisexuality, consecutive sexuality, rhythmical consecutive sexuality, alternative sexuality, and unisexuality, all are represented among the mollusks. Both the pelecypods and the gastropods have examples of all of these types, but the majority of species of pelecypods are unisexual while the gastropods are about evenly divided between unisexual and ambisexual species. The amphineurans show all types except alternative sexuality, although most of the species are unisexual. The scaphopods and cephalopods are strictly unisexual.

But little is known regarding the physical hereditary basis of sexuality in the mollusks, for only a few doubtful examples of heterochromosomes have been reported (Perrot, 1930). Several cases of environmental influence on the expression of sexuality in ambisexual species and on the sex ratios in unisexual species have been mentioned in a preceding section but no experimental proof of phenotypic sex determination has been obtained.

Certain species both in the pelecypods and in the gastropods are characterized by local races, some of which are unisexual and others ambisexual, and various species of gastropods may be either oviparous or ovoviviparous, according to the locality. Further experimental evidence is needed to determine the extent to which these differences can be influenced by environmental conditions.

In those cases of consecutive sexuality and rhythmical consecutive sexuality that have been mentioned in this and the preceding review (Coe, 1943), the primary sexual phase may be either male or female but it is usually male. Histological studies show that the developing gonad is more or less distinctly ambisexual, and that one of the two alternative sexual types of primary gonia continues to multiply, while the other type is usually inhibited. In a small proportion of individuals both types remain active and the young animal is functionally hermaphroditic. In the succeeding sexual phase either one type or the other may become dominant. In consequence there may be several simultaneous variants of the usual male-female-male sequence in a single population, as is well illustrated in the pelecypods by *Teredo navalis* and the larviparous oysters (Coe, 1943). Some individuals may be unisexual and others ambisexual.

In some of these cases it is histologically evident that the primary phase is female only when the usual male phase is aborted. Such an abortion can be produced in the gastropod *Crepidula* by subjecting the young individual to unfavorable conditions for a time and later returning it to a more suitable environment. The hereditary male tendency of the young individual appears to be inhibited until the time when the physiological conditions for femaleness have been reached. The oviparous oysters sometimes respond in a similar manner.

In all cases of consecutive sexuality, rhythmical consecutive sexuality, and alternative sexuality, each individual must be determined genetically for both the alternative phases of sexuality, with associated factors that determine which of the two phases shall be activated first. If the primary phase is to be male, as it usually is, the activity of the spermatic tissues is associated with the development of such specialized efferent ducts, seminal vesicles, and copulatory organs as may be characteristic of the species. Associated also are instinctive patterns of behavior peculiar to the male.

The inference may follow, although without definite proof, that the primary gonad releases such stimuli as are necessary to activate first the primordia of the accessory sex organs and later the nervous mechanism associated with behavior. This is, in general, in harmony with the observed histological differentiation of the organs.

It was mentioned that, in species of *Crepidula* and *Crucibulum*, the length of time that the individual remains in the male phase is influenced by environmental conditions, such as available nutrition and particularly by opportunity for copulation. The male phase can be terminated experimentally either by an unfavorable environment or by isolation. But in all normal individuals the male phase will come to an end under even the best conditions and this will generally, but with some exceptions, occur at approximately the same age in all the mated members of the population. The age, or size, at which the sexual transformation will normally begin varies with the species and is presumably conditioned upon a particular state of physiological maturity. There is doubtless an hereditary basis. There are also individual differences in the behavior of various young members of the population, for some of them remain solitary, either by chance or by choice, and experience only a brief male phase. Perhaps these differences may likewise be referred to various hereditary modifying factors.

The male phase, in species with consecutive sexuality, is unstable and indicative of immaturity but it may be long continued in an appropriate environment, such as is furnished by a suitable mate which provides satisfactory stimuli. When such stimuli are removed or become ineffectual, the female sexual phase ensues.

As stated in a previous review (Coe, 1943), all these manifestations of sexuality are consistent with the view that the prospective sexuality of the individual is dependent upon the quantitative balance of the male, as opposed to the female, factors in the hereditary mechanism. They may all be referred to the homozygosity or heterozygosity of the primary sex factors, with their associated modifying factors for the activation or suppression of either the male- or female-determining components at certain stages of development or in harmony with different degrees of physiological maturity. They are also responsive to environmental conditions.

Finally, the influence of internal secretions on sexuality may be considered. The presumably universal occurrence in vertebrates of hormonal substances necessary for the development and functional activity of the sex organs would seem to imply that secretions of a similar nature may be present in invertebrates. But as yet conclusive evidence to that effect has been found only in crustaceans and insects. There seems to be no satisfactory evidence that any substance of such a nature passes from an older to a younger individual, either in *Crepidula* or any other gastropod, as was formerly supposed to be the case and is so stated in many textbooks. There is no reason to believe that association is a prerequisite for either of the two sexual phases in any mollusk with consecutive sexuality.

In most invertebrates there is only a single set of primordia for the accessory sex organs, and these are generally homologous in the two sexes. But the organs which they form may differ greatly, presumably because the activating agency in the male, or in the male phase, is of a different nature from that in the female and activates different parts of the primordia. Each part appears to be attuned to a specific stimulus. In some of the mollusks, however, the copulatory organs of both sexes, but particularly of the male, have quite diverse origins.

In individuals with consecutive sexuality the parts peculiar to the primary sexual phase may be reduced to a simplified or neutral condition at the time of sexual transformation. The system is later redifferentiated by the agencies of the succeeding sexual phase in harmony with the functional requirements of that phase. In hermaphrodites certain parts of the primordia become differentiated into organs of the male type at the same time that other parts are forming the female organs.

Functional activity, however, is dependent upon agencies additional to those which govern the differentiation of the organs; there must be mutual interaction of the organs themselves with other secreting and reacting systems, including the nervous system. Only then is physiological sexuality realized, and only then do the sexual instincts become operative.

Functional sexuality, therefore, requires the participation of a long series of hereditary reaction systems which are activated one after the other in orderly sequence under the influence of suitable external and internal conditions. The environmental requirements may change during successive stages of development. Each developmental event as it occurs is a response to a preceding action and in turn initiates the one that is to follow. If any one of these reactions fails to occur, either because of hereditary or environmental deficiency, functional sexuality is not realized, and the individual is incapable of sexual reproduction.

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THE EMBRYOLOGY OF VERTEBRATE PIGMENT CELLS

PART II. BIRDS

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THE discovery that some of the migratory cells of the neural crest in birds become the definitive melanophores has served to stimulate experimental studies of pigment cell embryology. The present review surveys these more recent investigations in so far as they have to do with origin, migration, and special activities of the chromatophores. Among these special activities perhaps the one of greatest interest is the release of pigment granules by the melanophores to the barb and barbule cells of the developing feather (Plate I, Fig. 5). That it is by this remarkable process that the feather acquires its pigmentation has long been known (Aeby, 1885; Klee, 1886; Kölliker, 1887; Haecker, 1890; Post, 1894; Strong, 1902; Champy, 1935; and, especially, Watterson, 1942). On the other hand, the embryology of the feather and the production of the so-called structural colors lie beyond the limits of this article. Those interested in the interplay of pigmentary and structural factors in producing the wide range of colors displayed by feathers should consult the review by Biedermann (1928a) and the comprehensive survey by Frank (1939).

Birds offer particularly favorable material for the study of pigmentation by virtue of the intimate relationship of the melanophore to the developing feather and because of the large number of color varieties of the domestic fowl. These differences in coloration, which depend upon known genetic factors, combined with the possibility of transplanting elements of the feathers or of the prospective pigment cells between embryos, facilitate geneticoembryological studies in this group of animals. These relationships permit analysis of the degree to which the chromatophore functions autonomously in the synthesis of pigment and, conversely, of the extent of the control of melanophore activity by the local tissue environment.

The primary step in the analysis of the activities of the pigment cells in the embryo and under various experimental conditions is the determination of their origin.

ORIGIN OF MELANOPHORES IN BIRDS

The principal views advanced in the past as to the origin of pigment cells in birds are similar to those which have been held for other vertebrates (see Part I of this review, Du Shane, 1943). These opinions fall into two general categories, as follows:

(1) *Intrinsic or epidermal origin.* The fact that the differentiated pigment cells of birds first become visible in the epidermis of embryos or in the regenerating feathers of adults has led a considerable number of investigators to contend that they develop *in situ.* Among those who have supported this view on the basis of embryonic development are Jeffries (1883), Rabl (1894), Strong (1902), Kawamura (1934), Hosker (1936), and von der Eldern (1936). Others, studying the development of pigment cells in the regenerating feathers, came to a similar conclusion (Post, 1894; Lloyd-Jones, 1915; and Greite, 1934).

(2) *Extrinsic origin.* A number of investigators have thought that the prospective pigment cells migrate into the epidermis as colorless cells which later acquire pigment. The majority of those who have held to this view of the extrinsic origin of melanophores have thought they were modified connective tissue cells derived from the dermis (Kerbert, 1876; Klee, 1886; Kölliker, 1887; Haecker, 1890; and Champy, 1935). Aeby (1885) was of the opinion that the pigment cells were leucocytes which obtained their pigment by phagocytosis and digestion of red blood cells and then, as he put it, passed the pigment into the epidermal cells of the feather as *Bau und Nährstoff.*

More recent work confirms the extrinsic origin of the pigment cells and supports the hypothesis first advanced in general form by Weidenreich (1912) that the pigment cells are derived from the neural crest (see Part I). The experimental confirmation of this contention, which has been advanced within the last few years, will be considered in detail below. It seems best to consider the papers in the order of publication to permit the development of the concept to unfold chronologically.

NEURAL CREST THEORY

Dorris (1936) was the first to advance any experimental evidence in support of this idea as applied to birds. She explanted thin strips of the neural folds anterior to the first somite in six to ten somite embryos of several pigmented breeds of domestic fowl (Fig. 1). Actively ameboid, branched pigment cells developed in the cultures. On the other hand, similar explants of other tissues and of pieces of whole embryos which had been deprived of their neural folds failed to form melanophores. Her proposal that this indicated neural crest origin of the melanophores was not at first appreciated by others working in this field.

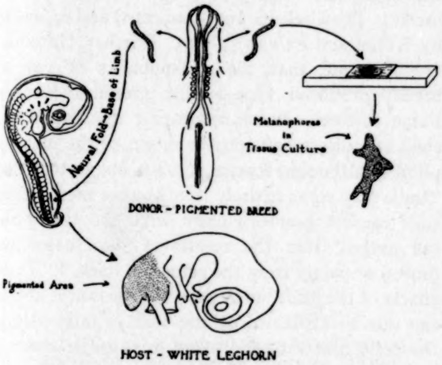


FIG. 1. DIAGRAM ILLUSTRATING SOME PHASES OF DORRIS'S WORK (1936, 1938, 1939)

Neural folds of the donor embryo produce pigment cells in tissue culture and when grafted to the base of the limb bud of another embryo.

Results obtained by Willier, Rawles, and Hadorn (1937) did not seem to support this interpretation. They transplanted epidermis of 75-hour chick embryos to the flank or wing-bud region of other embryos of different breeds. White hosts with grafts derived from pigmented donors showed areas of colored plumage of greater extent than would have been expected to have arisen from the grafted epidermis. Several hypotheses to account for this spread of pigmentation were advanced, but these were later withdrawn (Willier and Rawles, 1940) when it became apparent that the prospective pigment cells of neural crest origin had already penetrated the epidermis at the stages used in these experiments. In the light of further experiments it is now apparent that the prospective pigment cells in the minute piece of grafted epidermis had migrated into the neighboring host epidermis and had subsequently become incorporated in the developing feathers.

In 1938 Dorris extended her observations on the development of pigment cells in tissue culture and in 1939 reported the results obtained by grafting neural crest tissue into the limb buds of three-day embryos. As a result of this operation extensive areas of the host plumage became donor-colored. Dorris (1938) cited three lines of evidence which supported the neural crest hypothesis: (1) Cultures of neural folds of young embryos gave the highest percentage of positive results and developed the greatest numbers of melanophores. She interpreted this as indicating that at these stages the neural crest cells were concentrated at the one point and hence a large number of prospective pigment cells were explanted. (2) Head ectoderm and mesoderm or head ectoderm alone of early embryos did not give rise to pigment cells in cultures. (3) On the other hand, head mesenchyme and epidermis of older embryos formed pigment cells. She assumed that in these later embryonic stages the head mesenchyme or epidermis already contained the migratory crest cells which alone were capable of differentiating as melanophores. This type of evidence is similar to that advanced in explaining comparable results in the pigmentation of the limb bud of amphibia (see Part I). Such evidence, particularly in connection with the proof of neural crest origin of pigment cells in amphibians, led Dorris to say (p. 332): "These facts prove beyond any reasonable doubt that the pigmented cells obtained in the cultures described here have had their source of origin in the neural crest, and indicate the possibility of this region as a source of the pigment so conspicuous in the skin and connective tissue of the black breeds."

Willier and Rawles (1938), in extending their earlier experiments, grafted minute pieces of head epidermis or of what they termed "pure mesenchyme" between three-day embryos of Silkie and other breeds with ordinary plumage. The differences between the donor and host feathers (normal vane versus the fluffy barbless vane of the Silkie) made possible a clear decision as to the character of the feathers in the region of the graft. In such combinations the feathers were of host form in all instances, but the pigmentation of a large number of the feathers was of the donor type. They concluded that in some way the color or color pattern of the feather "is produced under the control of the implanted cells." The neural crest hypothesis was not advanced, although the possibility of migration of donor chromatophores into the base (collar) of the host feathers was suggested as an alternative to the release of some diffusible substance from the donor cells, which, in turn, affected the pigmentation of the host feather. It is now clear (Willier and Rawles, 1940) that the prospective melanophores had already entered the epidermis and mesenchyme at these stages and consequently migrated into the host tissues after grafting.

In this connection it is of interest that Holmdahl's (1928) careful studies of the normal development of the neural crest show that the head mesenchyme of birds and mammals is for the most part derived from the neural crest just as it is in the amphibia. Consequently it is likely that the "pure mesenchyme" referred to by Willier and Rawles above is largely if not entirely a product of the ganglion crest. Holmdahl also found neural crest cells laterally situated between the somite or myotome and the epidermis (see Fig. 4). As the experiments reported here suggest these migratory cells are in all probability the future melanoblasts which ultimately penetrate the epidermis and supply pigment to the feather.

SPECIFICITY OF MELANIN GRANULES

That the donor pigment cells actually supplied the pigment granules to host feathers was beautifully demonstrated by Rawles (1939). Small bits of head or wing-bud epidermis with a few adhering "mesoderm" cells were removed from robin embryos, which were equivalent in stage of development to chicks of 90 to 96 hours of incubation, and transplanted to the base of the wing bud of three-day White Leghorn embryos. The down feathers of the newly-hatched chicks were unquestionably of White Leghorn (host) origin, but those of a considerable area of the wing and the adjacent body regions were robin-colored (pale cinnamon to blackish-brown, Plate I, Fig. 6). Microscopic examination revealed that the pigment granules in the colored feathers were in the form of relatively large rodlets identical in shape, size, and color to those found in the feathers of robin. The granules, situated within the barb and barbule cells of the host feathers, were thus unquestionably derived from some of the grafted cells. Ladebeck (1923) had observed that the pigment granules in several breeds of the common fowl differed from one another in characteristic and consistent fashion. Danforth (1937) noted that such differences in the character of the granules persisted in chimaeric feathers at the edges of skin grafts (Plate I, Figs. 7a and 7b) and Rawles observed a similar constancy in various graft combinations between pigmented domestic breeds (Barred Plymouth Rock, New Hampshire Red, Black Minorca and F_1 Hybrid Blacks) and the White Leghorn. In each instance the pigment cells of graft origin show the form and color characteristic of the donor breed. These results were confirmed and extended by Willier and Rawles (1940). Further, Hamilton (1940) found that the melanoblasts of various breeds produced type-specific granules even in tissue culture. These interesting results did not shed any direct light on the origin of the melanophores, although Rawles (1939) suggested that "these may come entirely from the few mesodermal cells carried over originally with the transplant (as judged from the results of pure mesoderm grafts) or partly from the ectoderm itself." These effects of the graft, as in the other instances above, can now be explained on the basis of migration of the crest cells into the tissue prior to its removal for transplantation.

Eastlick (1939a), transplanting limb-bud primordia of 40- to 70-hour chick embryos to the coelome or body wall of the same or other breeds, obtained results which were consistent with the neural crest hypothesis. He found that if the cuts made in separating the limb bud from the donor embryos passed some distance from the neural tube and its associated neural crest, the resulting limb was non-pigmented. If, however, the cuts were made directly lateral to the neural tube, the resulting limbs developed donor pigmentation. In accordance with Dorris and with the interpretation of essentially similar results obtained in the amphibia (see Part I), Eastlick expressed the opinion that in grafts of the latter type some neural crest cells were included. In explanation of the former instances he suggested that the neural crest cells have not yet migrated into those primordia which were separated from the body by the more lateral cuts (Fig. 2). Eastlick interpreted his own and other experiments mentioned above in terms of the neural crest hypothesis and showed for the first time how all results obtained were consistent with this view.

Rawles (1940a), accepting the neural crest origin of pigment cells, attempted to localize their primordia more closely in early embryos. Independently and almost simultaneously, Eastlick (1940) reported experiments similar in conception and results. By grafting small areas of the blastoderm (mainly Barred Plymouth Rocks) of primitive streak and head process stages into the wing-bud area of White Leghorn or Rhode Island Red embryos Rawles was able to map the area of the blastoderm which was capable of giving rise to pigment cells. This area centered around the node and the head process (Fig. 3) and thus corresponded precisely with the area capable of forming neural tissue (brain, spinal cord, and ganglia) in chorio-allantoic grafts (Rawles, 1936; Rudnick, 1938). At later stages, after the elevation and folding of the neural tube, the entire medullary area is still capable of differentiating into pigment cells. It is only later that this potentiality becomes definitely restricted to the neural crest alone as the experiments described below indicate. Eastlick's results were in good agreement with those of Rawles.

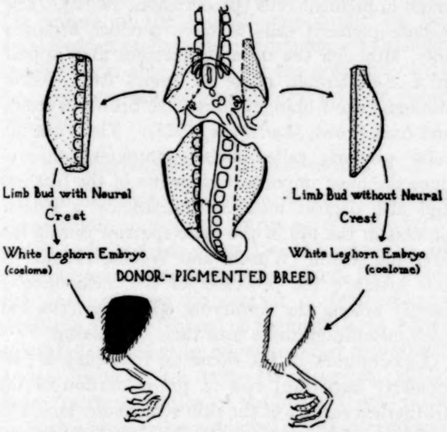

Limb Bud with Neural Crest
White Leghorn Embryo (coelome)
DONOR-PIGMENTED BREED
Limb Bud without Neural Crest
White Leghorn Embryo (coelome)

FIG. 2. DIAGRAM ILLUSTRATING THE METHOD OF GRAFTING EMPLOYED BY EASTLICK (1939b)

The limb primordia are grafted with or without accompanying neural crest cells, depending upon the level of the cut made in removing the limb. If crest cells are included the limb develops pigment.

Ris (1941), using operations similar in principle to those introduced by Eastlick, confirmed the neural crest origin of pigment cells. His particular contribution was to ascertain with greater certainty the state of development and degree of migration of the neural crest cells by preserving and sectioning the donor embryos. By this method it was possible to judge the likelihood of the inclusion of crest cells in any particular graft with considerable reliability. In one series of five operations on embryos of 23 to 31 somites, Ris cut close to the neural tube in removing the piece to be grafted. In two instances, examination of the donor embryos showed that on the side opposite to the cut, the neural crest had already migrated from its dorsal position. Both grafts became pigmented and there is a strong presumption that neural crest cells were included in each. In the other three embryos the neural crest had not yet formed at the level of operations (two cases) or was formed but had not yet migrated (one case). None of these grafts gave rise to melanophores. In a somewhat more extensive series of operations performed on embryos of from 9 to 37 somites, Ris transplanted the dorsal and ventral halves of the spinal cord.

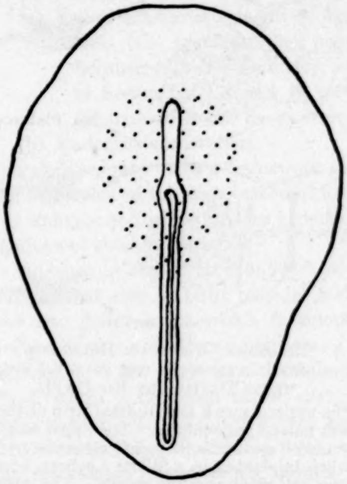


FIG. 3. DIAGRAM OF A CHICK EMBRYO IN THE HEAD PROCESS STAGE

The stippled area is capable of giving rise to melanophores in host feathers when grafted. The area corresponds to the region which produces neural tissue (brain and ganglia) in chorio-allantoic grafts. Comparison with Fig. 4 shows that the pigment-forming region becomes ultimately restricted to the neural crest alone. Redrawn from Rawles (1940).

The dorsal half, which of course included the neural crest primordium or detached neural crest cells, invariably gave rise to pigment cells (nine cases)—as must indeed have been anticipated from the experiments reported earlier by Dorris. The ventral halves formed pigment only when it might have been expected that the neural crest cells would have migrated to the level of the ventral halves of the cord as judged by their development in normal embryos of similar stages (Fig. 4). Ris further pointed out that the ability to form melanophores was present in the entire neural tube primordium in early stages (Rawles, Eastlick), but that this capacity rapidly became limited to the neural crest alone.

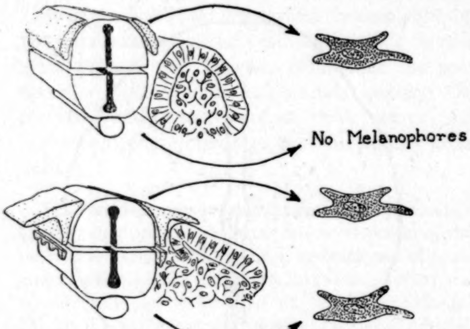


FIG. 4. DIAGRAMS (BASED ON HOLMDAHL'S (1928) FIGURES) ILLUSTRATING ONE OF THE EXPERIMENTS DEVISED BY RIS (1940)

In the upper figure a longitudinal strip of the neural tube was halved horizontally. The upper half, including the neural crest cells (stippled) gives rise to pigment cells when implanted in a White Leghorn host, while the lower half gives negative results. The lower figure illustrates the results obtained after migration of the neural crest has begun. Both pieces now include neural crest cells and both differentiate melanophores when grafted.

PIGMENT OF THE EYE

Ris (1941) was the first to advance evidence that the melanophores of the choroid coat of the eye likewise have a neural crest origin. He grafted optic vesicle alone (prior to the migration of the neural crest) or optic vesicle together with the adjacent part of the fore brain (i.e. including the neural crest primordium). In the former case, the pigment epithelium of the retina differentiated but no melanophores appeared; in the latter, both pigment epithelium and melanophores differentiated. As in the skin, the melanophores of the eye are neural crest derivatives as Barden (1942) later found in the amphibians (cf. p. 118, Part I of this review).

DISTRIBUTION OF NON-CHROMATOPHORIC PIGMENTS

The occurrence of pigments, aside from those produced by or contained in the specialized pigment cells of birds, is perhaps beyond the scope of this article. It should, however, be emphasized that lipochromes in lower vertebrates are contained mainly in chromatophores (xanthophores, allophores, lipophores, etc.) while pigments of similar solubility and coloration in birds have never been found in pigment cells (Biedermann, 1928a). The stellate pigment cells of birds produce melanins only, although the melanin granules may appear in a considerable range of colors from yellow through yellow-orange and reddish-brown to brown and dark brown (Ladebeck, 1923). These are the cells—properly called melanophores—which produce the most important pigments of the feathers and also deposit melanin granules by a similar process in the bill of the male sparrow during the breeding season (Witschi and Woods, 1936). In this instance the processes of the melanophores ramify among the cornifying epidermal cells and pass melanin granules into their cytoplasm.

Lipochromes in the domestic fowl play a particularly important rôle in the coloration of the featherless regions of the skin such as the face, legs and feet. In some birds they give the main coloration to the feather itself (Krukenberg, 1886; and, for an introduction to the more recent literature, see Test, 1942; Kritzler, 1943). Such lipochromes (carotenoids) appear to be associated mainly with the malpighian layer of the epidermis.

As early as 1844, Bruch found fatty yellow or red droplets of pigment in the epidermis of the bills of ducks, geese, and doves. In addition, he noted that in the bill of the male duck there are melanophores in the epidermis and dermis, which, in combination with the yellow pigment, produce a green color. Wurm (1871) described a red lipochrome in the head epidermis of the mountain cock and an orange lipochrome in the epidermis of the European ruffed grouse. More recently Regnier (1926) has reported the presence of orange-red lipochrome droplets in the malpighian layer of the epidermis of the head of the pheasant. These droplets, together with a rich capillary plexus in the dermis, produce the scarlet coloration. Lipochromes in the same layer of the epidermis are responsible for the bright yellow of the skin of the oral cavities of young blackbirds (Schmidt, 1918).

According to Ladebeck (*loc. cit.*) the color of the combs and wattles of the domestic fowl depends entirely on the color of the blood in the highly-developed capillary network in the superficial corium, since he was unable to find any trace of pigment in these structures. Quite a different mechanism is responsible for the white color of the ear-lobes in the fowl. These appendages lack the superficial capillary plexus of the comb and wattles and have an especially dense corium, the connective tissue fibres of which show a weak double refraction and appear white in reflected light. The nature of the crystals responsible for the double refraction has not been determined although Ladebeck was able to rule out the possibility that they were crystals of guanin, uric acid, or lipoid substances.

DISTRIBUTION OF MELANOPHORES

It will be recalled that in lower vertebrates the pigment cells occur in all deeper parts of the body as well as in the skin (Part I of this review). In birds and mammals, on the other hand, ***pari passu*** with the extensive elaboration of feathers and hairs, the deeper sheets of pigment have either entirely disappeared or have remained as vestiges in some parts of the body (Weidenreich, 1912). Hence, in the evolution of the higher forms, there has been a progressive reduction of the visceral and dermal pigment cells with the result that the largest accumulation of melanophores is now confined to the epidermis alone. In most adult birds visible melanophores are present only in the epidermis of the feather bases during growth or regeneration.

Before considering the experimental work which bears on the genesis of this restricted distribution of visible pigment cells, it is appropriate to outline the possible developmental events involved.

Since the only demonstrable source of melanophores in birds is the embryonic neural crest, we may assume that the potential pigment cells spread out from the neural tube to reach their final locations. Several postulates suggest themselves, as follows:

(1) The melanoblasts may migrate to the epidermis alone (selective migration). This seems unlikely as a general hypothesis in view of the fact that pigment cells appear in the deeper positions in some birds and that neural crest cells moving medial to the somites are capable of forming melanophores (Eastlick, 1939b; Ris, 1941). However, Ris noted that in chicks of black breeds at hatching there is a distinct line of melanophores at the umbilicus. The mesenchyme at this point is irregularly arranged and perhaps forms a barrier to melanophore migration. Ris suggests that mechanical barriers may also prevent migration of melanophores into the mesenteries in pigmented breeds.

(2) The melanoblasts may migrate into all parts of the body as they do in the amphibia. In the deeper parts of the body they may:
   (a) Fail to differentiate as visible pigment cells (i.e. synthesize no pigment) because of local inhibitory factors or because of the lack of essential substances in the environment; or
   (b) Undergo degeneration.

These possibilities may form a framework for the following discussion of the distribution of melanophores in embryos and adults and the experimental investigations of their migrations.

Some evidence in regard to the distribution of potential pigment cells in birds may be gathered from the few instances in which melanophores occur in the dermis and deeper positions. With the exception of a few pigmented birds and the Silkie fowl, which is discussed below, distinctive melanophores have been described only in association with the testes. Leydig (1857, p. 494) noticed that the convoluted seminiferous tubules were colored black in one testis and colorless in the other in specimens of the wagtail, ***Motacilla alba***, and the bullfinch, ***Pyrrhula***. Solger (1886) added two other examples of asymmetrical testicular pigmentation in birds. The left testis of the swift, ***Cypselus apus***, appeared gray-black grossly and contained numerous melanophores in the interstitial tissue between the seminiferous tubules. The right testis was devoid of pigment cells. The small right testis of another bird (apparently a small gull or sea-mew referred to as a ***Broncemännchen*** or ***Broncemövchen***) was similarly pigmented while the larger left testis was colorless.

Pigment occasionally occurs in one or both embryonic testes of the common fowl. Thus Minoura (1921) described five embryos with left testes only pigmented and one with both pigmented. Similar and more extensive observations on gonadal pigment were made by Willier and Yuh (1928) both in normal and experimentally treated chick embryos. They describe with care the distribution of the pigment macroscopically. Since there was no apparent effect of their experimental treatment on the pigmentation, it seems permissible to group the results. Gonadal pigmentation was not found in any of the Brown Leghorn (502) or White Leghorn (96) embyros. Gonadal pigment did occur in a total of twenty embryos out of a group of 344 (318 mixed breed and 26 Barred Plymouth Rock). In one female there was slight pigmentation of the left ovary; in eleven males the left testis only was pigmented; in eight males both testes were pigmented, the left being in all cases darker. In two of the latter, pigment was scattered over the peritoneum, especially that covering the Wolffian duct.

Danforth (personal communication) states that pigment commonly occurs in one or both testes of the domestic fowl; pigmentation of the ovaries is less frequent. Testicular as well as ovarian pigmentation appears regularly in the pheasants; in these forms, as in the fowl, the coloration is often asymmetrical, the left testis generally being the darker.

Judging by these scattered observations gonadal pigmentation shows a marked asymmetry, tending to be more heavily or even exclusively present in the left gonad. However, in the starling, *Sturnus vulgaris*, Bissonnette (1930a, 1930b) found dark heavy black pigment in the interstitial tissue of both testes where he described it as "deposited in dense round flakes between the tubules and only a few blood vessels in the inner layers of the tunica albuginea." Bullough (1942) recognized definite pigment cells in similar positions in the testes of the European starling. The observations of both authors mentioned above indicate that heavy testicular pigmentation in this species is of regular occurrence.

These observations indicate that, in these forms at least, melanoblasts penetrate the testes. It is difficult to avoid advancing the suggestion that the migration of potential pigment cells is perhaps much more widespread than this. In the majority of birds the conditions in the dermis and deeper sites may be unfavorable to the formation of pigment or to the viability of the cells; in a few birds one visceral organ, the testis, seems to provide a suitable environment for pigment formation by the prospective melanophores; finally, in one highly selected breed of fowl, the White Silkie, potential pigment cells come to expression in virtually all parts of the body save the epidermis and feathers. The arrangement of pigment cells in the Silkie is consequently a matter of broad interest.

Kuklenski (1915) studied the distribution of pigment cells in the White Silkie and found that they were present in all of the sites distinguished by Weidenreich (*loc. cit.*) in the lower vertebrates except the epidermis. Thus, melanophores occurred in great abundance in the dermis and subcutaneous layers, in the dura mater and pia mater (perineural coat), in the parietal and visceral coelomic sheets (pericoelomic coat), and in association with blood vessels (perivascular coat). Pigment cells were also particularly numerous in the stroma of many of the visceral organs and in the periosteum and perichondrium. The density of the subcutaneous pigmentation is such that after removal of the skin the body still appears black. The skin itself is black in gross appearance because of two dense layers of melanophores, one immediately beneath the epidermis and one deep in the corium. Concerning the pigmentation about the skeleton, Kuklenski says (p. 23, in translation): "The superficial black color of the bones is brought about by the presence of numerous chromatophores in the periosteum which covers over all bones with a uniform blackness and the entire skeleton looks as though it were carved out of ebony." The bones have the natural coloration after removal of the periosteum.

The pigmentation of the gonads is perhaps of greater interest because of the other instances cited above. In the testes pigment cells occur in large numbers in the tunica albuginea and among the interstitial cells between the seminiferous tubules. The ovary is even more heavily pigmented than the testis, melanophores occurring in the stroma and the empty follicles.

There are also scattered references to pigment cells in the deeper position in other varieties of the common fowl although no systematic study of their distribution has been published. Thus both Dorris (1939) and Ris (1941) refer to the presence of melanophores in the dermis and connective tissues of breeds with colored feathers. Ris (p. 62) reports that the mesenteries of several pigmented breeds contain no melanophores. According to his statement melanophores move into the mesenteries only if a pigmented graft is attached to it. He regards this as evidence that "something must inhibit the migration of melanophores into the mesentery during normal development." It may be pointed out that this inhibition of migration may be merely apparent since it is possible that unpigmented melanoblasts enter the mesenteries and only develop pigment under the favorable conditions obtaining when a pigmented graft is present (cf. below). However, Eastlick (1938, 1939) found that limb grafts attached to the coelome failed to become pigmented and Rawles (1942) has used this method of grafting to obtain wings devoid of host melanophores.

In summary, it may be suggested that variable numbers of pigment cells may occur in the corium and deeper positions among the mesenteries of some embryonic and newly hatched birds. In some birds they are particularly abundant in the interstitial tissue of the testes; in the Silkie fowl they occur in connective tissue throughout the body. Such a distribution implies a widespread migration of melanoblasts to all parts of the body —at least in some forms.

From the paucity or absence of visceral pigment cells in typical adult birds and their presence in the testes alone in some birds, it seems reasonable to propose that in most instances the melanoblasts reaching the viscera either fail to express themselves as visible pigment cells or undergo degeneration in most sites. It would be desirable to investigate the relationships involved here by transplanting neural crest cells between the Silkie and other breeds of fowl. In grafts from the Silkie to ordinary breeds one could test the connection between pigment cell differentiation and position. If the deeper tissues of the host become heavily pigmented, as in the donor, one could assume pigment cell autonomy. If, however, the results were negative and positive effects were obtained only in the reciprocal combination, the dependence of the potential pigment cells on the local environment (i.e. as in the white axolotl; cf. Part I of this review) would be indicated.

Unfortunately, no experiments have been performed with particular attention to the visceral melanophores. There is, however, some evidence that neural crest cells moving toward the viscera are capable of playing a normal pigmentary rôle in the feather when transplanted in such a way that they enter the host epidermis. Ris (1941) found that neural crest cells moving between the somite and the neural tube—and hence toward the viscera rather than the skin—were capable of forming melanophores in the coelomic epithelium, the mesenteries, and the skin and feathers.

Further support of the view that the neural crest cells migrating toward the visceral organs are capable of entering the feather germ and depositing pigment may be derived from the transplants by Eastlick (1939b) of White Leghorn limb buds into the coelomic cavity of Brown Leghorn embryos. The host melanoblasts apparently failed to migrate into the graft limb when it was connected to the host by a slender strand of mesentery. However, those limbs which were rather broadly connected to the inner side of the body wall (parietal peritoneum) acquired host pigmentation in their plumage by immigration of melanoblasts. Here again it seems clear that those cells would not normally have reached the skin, but would have remained in subcutaneous or deeper positions.

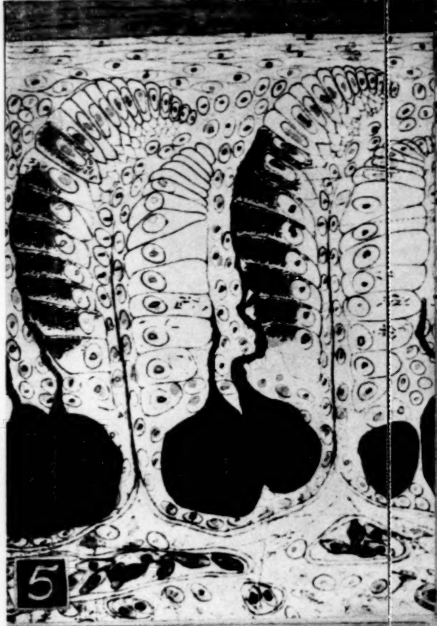
Even more striking effects have been obtained recently by Rawles (personal communication). Wing buds of three-day White Leghorns were grafted into the coelomic cavities of slightly younger Barred Rock embryos. The grafts attached to the inner surface of the body wall received the immigrant host melanoblasts and developed dark down plumage. The graft skin was regrafted at the time of hatching to the back region of White Leghorn hosts. By this means Rawles obtained skin chimeras made up of White Leghorn epidermal and dermal components and Barred Rock melanophores and melanoblasts. The Barred Rock melanophores laid down barred patterns in the adult White Leghorn feathers.

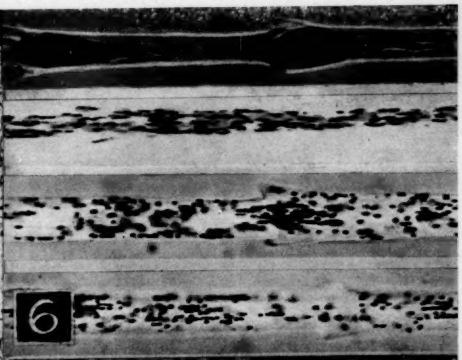
The above observations indicate that the deeper potential melanoblasts—many of which would probably never normally develop pigment and none of which would ordinarily reach the epidermis—are capable of responding to the local environment at the base of the feather by becoming typical feather melanophores with all of the complex topographical and physiological modifications which this differentiation entails.

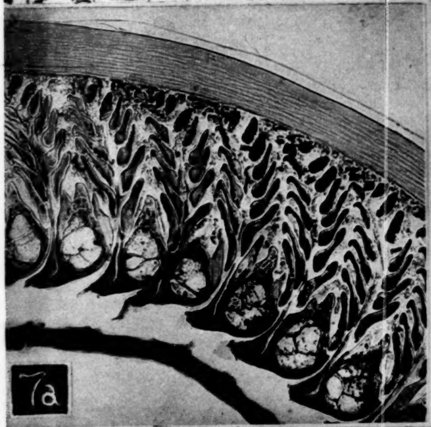
OTHER ASPECTS OF MELANOBLAST MIGRATION

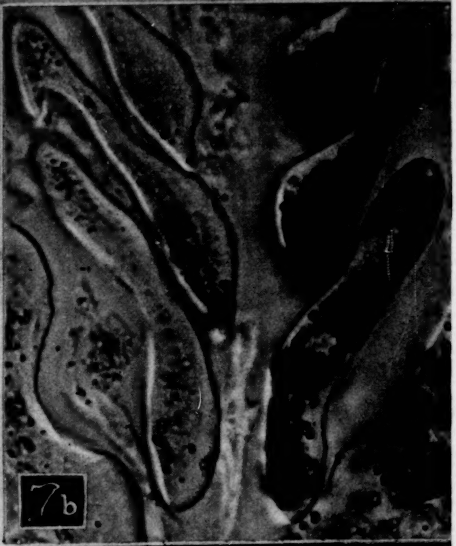
The temporal relations of melanoblast migration have been determined somewhat indirectly by transplantation experiments. Willier and Rawles (1940) have made the most extensive observations bearing on this point in a series of operations carried out on embryos of different ages. They find that melanoblasts are present, as indicated by the later development of donor-colored plumage, in the epidermis and mesenchyme of the head and trunk (somite level) of embryos as young as 62 hours incubation age. At this stage, tissues more distant from the neural crest such as the wing bud have

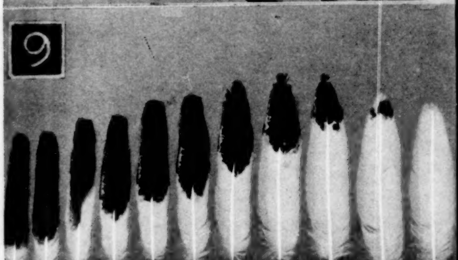
PLATE I







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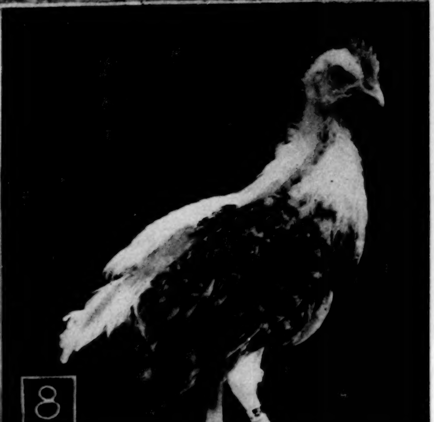

FIGS. 5–9

not yet received prospective pigment cells, as judged by the failure of such grafts to give rise to melanophores. Melanophores apparently reach the wing-bud epidermis and mesenchyme when the embryos have been incubated about 80 hours.

On the basis of this information Watterson (1942) made a careful histological study at hourly intervals of wing-bud epidermis of embryos from 75 to 96 hours of incubation. He found cells apparently passing from the mesenchyme to the epidermis in embryos of 80 to 91 hours of incubation with the peak of migration (seven or eight cells) at 82 hours. These cells could be distinguished from epidermal or dermal cells only by the possession of an enlarged nucleolus. Their identification as melanoblasts was based upon their position (i.e. apparently passing from dermis to epidermis) and the fact that their first appearance corresponded to the earliest stage at which Willier and Rawles (*v.s.*) found donor-colored areas from transplants of wing-bud epidermis. The difficulty of identifying these cells as melanoblasts is due to the fact that melanin production does not begin until after seven to seven and one-half days of incubation.

The migration of melanoblasts into the posterior limb bud occurs considerably later. Limb-bud ectoderm of 94- to 103-hour embryos failed to produce donor-colored plumage when transplanted, the first positive results being obtained at 132 hours (Willier and Rawles, p. 179).

Willier, Rawles, and Hadorn (1937), Willier and Rawles (1938, 1940), Dorris (1939), and Eastlick (1939b) have noted the extensive spreading of donor melanophores from the point of engraftment. The experiments of Willier and his co-workers are particularly striking in that minute bits of mesenchyme or epidermis (containing migratory neural crest cells) implanted at the base of a wing bud give rise to extensive donor-colored areas of plumage. In some instances the donor melanophores color the host feathers of the saddle and breast as well as those of the entire wing (Plate I, Fig. 8).

This extensive dispersal of the pigment cells does not take place in skin grafts made after hatching (Danforth and Foster, 1929; Danforth, 1937, 1939a). In such grafts the feathers of the donor skin maintain their own pigmentary characteristics as do the feathers of the adjacent host skin (Plate I, Figs. 7a and 7b). It is only at the line of junction between the graft and host integument that there is evidence of limited migration. Along this line some feathers are pigmentary chimeras, receiving pigment granules from both host and donor areas. This points to a very limited migration of host cells into the bases of donor feathers and vice versa.

In explanation of the widespread migration of melanoblasts from embryonic grafts Willier and

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FIG. 5. Transverse section of a feather germ of a tern, *Sterna hirundo*. The pigment cells are shown passing their granules to the developing barbule cells. The feather sheath is above. × ca. 675. From Strong (1902). Cf. 7a which represents a similar section of an older feather from which the pigment cells have already disappeared.

FIG. 6. Unstained whole mounts of down barbules from the downy region of upper region of upper wing coverts. From Rawles (1939), × ca. 975. The topmost photograph shows the arrangement of pigment granules in the barbule of a robin; note the clumping of granules at the nodes and their slender, tapering shape. The following photograph shows a White Leghorn barbule containing pigment rodlets derived from robin melanophores transplanted in embryonic stages. The specificity of the granules is apparent. They show no tendency to clump at the nodes in the White Leghorn barbules. It should be noted that the White Leghorn barbule is normally devoid of pigment. The figure next to the bottom shows the normal pigmentation of a barred Plymouth Rock barbule; the bottommost photograph is of a White Leghorn barbule in which Barred Plymouth Rock melanophores grafted embryonically have deposited their ovoid granules. Photographs of other such combinations may be found in Willier and Rawles (1940).

FIG. 7a. Cross-section of a portion of a feather growing at the junction of Buff Leghorn skin transplanted to a Jersey Black Giant. The barbules on the left contain yellow granules deposited by the Buff Leghorn melanophores; those on the right at the zone of transition contain both black and yellow granules derived from the host and donor melanophores. From Danforth (1937), × ca. 171.

FIG. 7b. Parts of several barbules at the transition zone of the same feather as in Fig. 7a. Both black and yellow granules of pigment are present in the same cells. The black granules are elongate; the yellow globular. Due to the orientation of the black rods perpendicularly to the plane of section, this specific difference is not apparent. From Danforth (1937), × ca. 995.

FIG. 8. A 31-day old ♂ White Leghorn chick with feathers of wing and part of breast pigmented by granules derived from Barred Plymouth Rock melanophores. This was produced by grafting a piece of Barred Rock head epidermis (containing melanoblasts) to the base of the wing bud of the host embryo after 78 hours of incubation. The barred pattern set up in the host feathers is noteworthy. From Willier and Rawles (1940).

FIG. 9. Secondary feathers (2 to 12) of a White Leghorn chick which received an implant of head epidermis (containing melanoblasts) of a F_1 hybrid ♀ donor. Since these feathers are arranged in the order of their emergence from left to right this serves as a graphic scale of the persistence of graft pigment cells. The first feather to emerge (on the left) is almost totally pigmented, while each succeeding feather, emerging later, receives pigment for a shorter time than its predecessor. From Willier and Rawles (1940).

Rawles (1940) and Willier (1941) have pointed out that the grafts are placed in tissues into which the host melanophores have not yet penetrated. They have suggested that the donor melanoblasts spread out before the arrival of the host cells and preempt the available spaces in the epidermis. The prospective pigment cells of the host are somehow barred from immediate entry.

In support of this interpretation, Willier and Rawles (1940) cite their finding that, when the host embryos were one to two days older than those customarily used, there is much less extension of the donor-colored area. It is, as they indicate, probable that host melanoblasts have already moved into the wing bud in these older embryos. There are also breed differences in host embryos which affect the spread of the implanted melanophores. Thus, approximately the same quantities of implanted melanophores show relatively slight dispersal in Barred Plymouth Rock, White Wyandotte, and New Hampshire Red and extensive spread in White Leghorn or Black Minorca host embryos.

No conclusive statement can be made as to the time when melanophores lose the ability to migrate, although Hamilton (1940) found that the cells ceased ameboid movement in tissue culture when they became pigmented and he suggested that in birds migration of melanophores was inversely related to pigmentation (cf. Part I of this review). However, Humm (née Dorris) in 1942 found that cells which had been maintained as differentiated melanophores in culture for long periods (up to six months) still showed considerable ability to migrate along blood vessels, tendons, etc. when transplanted to embryos. The spread of the melanophores was, on the contrary, slight in the skin in contrast to the extensive migration of embryonic melanoblasts.

PERSISTENCE OF DONOR MELANOPHORES

It is the general experience of the authors mentioned above that the down plumage and often even the juvenile and the first adult feathers may be donor-colored. However, with each successive molt more and more of the feathers became host-colored; a result which suggests a gradual loss of the foreign melanophores and coincident invasion by host melanophores (cf. Willier and Rawles, 1940; Willier, 1941). This change from donor to host pigmentation may, however, occur quite rapidly in such a way as to suggest the sudden disappearance of the entire population of engrafted pigment cells (cf. Plate I, Fig. 9, from Willier and Rawles, 1940).

There is an important exception to this general loss of donor pigmentation. Rawles (personal communication) in the double operation described above found that the whole wing bud, removed from a White Leghorn before the entry of host melanoblasts and transplanted so as to receive Barred Rock melanophores, maintained its Barred Rock pigment through repeated molts after the skin was regrafted, at hatching, to a White Leghorn host.

What are the essential differences in the underlying factors which lead to loss of donor pigment on the one hand and persistence on the other? In the instances where donor-colored areas gradually disappear a relatively few crest cells (melanoblasts) were brought in with the graft; further, at least in later stages, we may assume that host cells of similar character mingle with them. In the latter case (Rawles) it seems likely that the organ (wing) receives its total complement of melanoblasts from the first host, with the consequence that there is little or no intermingling. With the production of each new adult feather the melanophores responsible for its pigmentation degenerate, as has long been known (for example, see papers by Strong, 1902; Watterson, 1942, etc.). This fact implies that there is a reservoir of colorless potential pigment cells which supply new melanophores to the regenerating feathers. The reservoir in the case of the total wing graft is pure (Barred Rock cells only) and adequate to supply the demands of the new feathers. In the usual embryonic operations, the pool of available graft cells is mixed (host and donor) and small in quantity. It is possible, as Willier and Rawles (1940) suggest, that local conditions may slightly favor the development of host melanophores thus leading to a gradual shift in the melanophore population.

SOURCE OF MELANOPHORES IN REGENERATING FEATHERS

As has already been mentioned, visible melanophores appear in the epidermis of adults only in association with the epidermal collar of the regenerating feather. There is no longer any question of their initial derivation from the neural crest; but what is their immediate source? Do they lie unrecognized in the epidermis itself only awaiting the differentiation of a new feather to become activated? Or are they situated in the dermis and move into the epidermis only during early development of the regenerating feather germ?

This question has been particularly emphasized by Willier and Rawles (1940) and has been the object of a special study (Foulks, 1943). Foulks' histological observations of regenerating feathers of young Barred Rock hens reveal that the first visible melanophores are found in the dermal papilla of the feather germ during the third day of regeneration. These pigment cells apply themselves to the epidermis, and, slightly later, cells of identical appearance are found amongst the epidermal cells. At this time other melanophores appear to lie partly in the dermis, partly in the epidermis, while still others, whose cell bodies are in the dermis, send branching pigmented processes between the epidermal cells. These findings, coupled with the observation that the melanophores in the papilla lie nearer the base of the feather than do those in the epidermis, form the morphological basis for Foulks' conclusion that the melanoblasts move from the dermal papilla into the epidermis in regenerating feathers. Foulks also grafted different parts of the feather germ at various stages of regeneration to the coelome and to the base of the limb bud of White Leghorn embryos. The development of melanophores in such transplants provides a test of the distribution of melanoblasts in the regenerate. The outcome of these grafting experiments, which involved portions of the dermal papilla alone as well as different parts of the whole regenerate, is consistent with the histological findings; that is, that melanoblasts move from dermis to epidermis in the early stages of regeneration. There are also strong indications that the "reservoir" of potential pigment cells apparently does not, as might have been expected, lie in the base of the feather primordium. Thus the feather germ, immediately after the adult feather is plucked, contains no visible melanophores and few melanoblasts. The number of the latter (estimated by the abundance of melanophores formed in transplanted parts of the feather germ) increases markedly in the first few days of regeneration. Foulks suggests that this result indicates that the "reservoir" of melanoblasts lies in the dermis largely outside of the base of the feather. This implies that these potential pigment cells remain undifferentiated in the dermis until a feather is plucked.

Foulks supports his opinion by evidence derived from the literature bearing on the pigmentation of skin grafts and of mosaic feathers. For example, Rawles (1942) reported that embryonic skin, removed prior to the migration of melanoblasts and transplanted to the coelome of White Leghorn embryos, remained colorless. At hatching, the transplanted skin, regrafted to a pigmented host, gradually acquired pigment of host type. Likewise Wang (1943) showed that the whole feather germs of adults acquired host pigmentation when transplanted. These results all point to an extrinsic source of pigment cells, i.e. the dermis.

MELANOPHORES OF WHITE BREEDS OF FOWL

The genetic analysis of White Leghorn pigmentation by Hadley (1913, 1914, 1915) indicated the presence of factors for barring and for black pigment. The expression of these genes in the White Leghorn and in the F_1 hybrids was masked or suppressed by a dominant "inhibiting" factor. On the other hand, in most colorless breeds white is recessive to color in hybrids.

It is of no little interest that our knowledge of the mode and time of action of both the dominant and recessive genes responsible for white coloration has been carried a step further by transplantation experiments (particularly, Willier and Rawles, 1940) and explantations (Dorris, 1938; Hamilton, 1940). Dorris (1939) had suggested that epidermis of the White Leghorn inhibited the formation of pigment by the melanophores. However, as Willier and Rawles point out, the ability of transplanted melanoblasts of other breeds to differentiate and to deposit pigment in White Leghorn feathers constitutes a strong reason for rejecting this hypothesis. This observation, coupled with their finding that White Leghorn melanoblasts produce only small areas of white feathers or even none at all in colored hosts, led them to suggest that the key to the problem might be found in the activities of the melanoblasts themselves.

A possible explanation of the different behavior of the melanoblasts of white and colored breeds in pigmenting the feathers was suggested by Hamilton (1940) on the basis of explantation experiments. He explanted skin of six- to seven-day embryos (containing prospective pigment cells) of a variety of breeds of the common fowl and of several other species. The prospective pigment cells of white as well as those of colored breeds elaborated melanin granules *in vitro*. In all instances the melanophores differentiated as ameboid cells and persisted in cultures for a variable length of time. Noteworthy differences were observed in the time of degeneration of pigment cells derived from recessive white breeds, the dominant white breed (White Leghorn) and colored breeds. The explanted melanophores from these sources persist respectively: two days; three to four days; and ten or more days (Barred Rock). Melanophores of the white hybrid (derived from a cross between Barred Rock female and White Leghorn male) had an intermediate life, degenerating in from three to six days after explantation.

The fact that all pigment cells have a limited life in the feather in normal birds should not be overlooked. These migrate into the epidermal base of the feather, deposit their melanin granules and then die. Those of white breeds undergo a somewhat earlier degeneration than do those of other breeds. In fact, Hamilton studied split preparations of several kinds of white feathers and found a few melanophores in the bases of the feathers of the White Leghorn and none in the feathers of three individuals of the White Wyandotte. Of two specimens of White Plymouth Rock one was devoid of melanophores, the other had a few degenerate melanophores confined to the base, that is, to the most embryonic part of the feather.

These studies suggest that the so-called inhibitor of the White Leghorn is a dominant factor affecting the viability of the melanoblasts. In the recessive white breeds, on the other hand, the factors affecting pigment cells act to limit melanophore life only when homozygous. Consequently, the whiteness of feathers in white breeds, either dominant or recessive, appears to be due to the fact that the pigment cells degenerate before they deposit significant numbers of melanin granules in the barb and barbule cells of the developing feather (cf. Hamilton).

It is the particular merit of this essentially embryological approach that the abstract genetic concept of a dominant "inhibitor" in the White Leghorn has been refined and rendered more concrete. The genes appear to act directly upon the melanophores themselves as modifiers of their viability, or, to put it in other terms, as factors affecting the rate of expression of the "lethal" factors which may perhaps be assumed to be common to all varieties of melanophores.

CONTROL OF FEATHER PATTERN BY MELANOPHORES

The production of type-specific granules in host feathers by grafted melanophores has been referred to above. Of equal interest is the action of donor melanophores in forming characteristic barred or multi-colored patterns in individual host feathers. Some examples of this have already been discussed. For a more detailed consideration than the following, the reader is referred to the work of Willier and Rawles (1940) and to the reviews by Willier (1941, 1942 a and b).

If we may, for the moment, disregard extrinsic modifying factors, it is apparent that melanophores from different breeds or species produce characteristic donor color patterns in a wide variety of host feathers (see Willier, 1941). Thus, Black or Buff Minorca melanophores lay down uniform donor patterns in White Leghorn feathers. Brown Leghorn, Barred Rock, guinea fowl, New Hampshire Red, robin, etc. melanophores likewise produce specific donor barred or multi-colored patterns in host feathers of any breed. These results, only some of which are mentioned here, indicate that the genetic composition of the melanophores in the various breeds is a decisive factor in determining feather pattern.

Barred Rock melanophores elaborate barred patterns in the contour feathers of such diverse non-barred hosts as the New Hampshire Red, White Leghorn, Black Minorca and a Mongolian pheasant (Rawles, unpublished results cited from Willier, 1941).

The nicety of this control of pattern by the Barred Rock melanophores is shown by the occurrence of two types of barring produced in host feathers. In the one the black bars are both wider and darker than in the other. These differences are as Willier points out "similar to sex-linked differences in plumage found in donor control chick of the same age where female plumage is darker than the male. The comparison indicates that a melanophore from a female donor which has only one gene for barring produces a darker-colored host feather than one for a male which has two genes." This interpretation of the difference between the sexes was first suggested by Spillman (1908) in his study of the genetics of barring in which he made the point that the barring factor acts as an inhibitor of melanin deposition. However, Watterson's (1942) observation that the melanophores of the female Barred Rock embryo contain more melanin than those of the male from the time of their first appearance led him to suggest that the barring genes act directly within the melanophores, i.e. upon the process of melanin formation rather than upon that of melanin deposition in the barb and barbule cells. According to this explanation, the cock, being homozygous (having two factors for barring), would have narrower black and wider white bars in its feathers than the female, which, being heterozygous, has only one factor inhibiting melanin formation in the pigment cells. The fact that castration in Barred Rock males and females has no effect on the plumage pattern (Montalenti, 1934) offers additional evidence of the primary importance of the genes acting within the melanophores rather than through the intermediation of sex hormones.

Genetic studies (Spillman, 1908; Pearl and Surface, 1910; Morgan and Goodale, 1912) have revealed that the dominant barring factor is sex-linked. This relationship has made possible an extension of the analysis of the mode of gene action by transplanting melanophores from F_1 hybrid embryos derived from Barred Rock ♀ × Rhode Island Red ♂ crosses (Willier, 1941). The hybrid cocks are heterozygous for barring and show barred feathers, while the females, lacking the barring gene, are black. Willier (*loc. cit.*) reports the results of transplanting melanophores of such hybrid embryos to the White Leghorn. The sex of the donor was determined in each instance at hatching. The results illustrate strikingly the autonomy of the melanophores in producing barring, since those from F_1 males lay down a barred pattern in the contour feathers of hosts of either sex. Similarly, the melanophores from female hybrids produce black (non-barred) regions in the host feathers regardless of sex. The gene affecting barring thus acts directly upon the melanophore itself.

Willier's findings should be compared to those of Danforth (1929) whose observations pointed to the same conclusion: the autonomy of the barred pattern. Danforth transplanted skin at hatching from a hybrid (Plymouth Rock ♀ × Rhode Island Red ♂) to a female hybrid chick (Bantam ♀ × Rhode Island Red ♂). The male offspring from the cross which furnished the graft are barred and the females non-barred, while the host chick is non-barred. The point of major interest is that the graft skin produced barred feathers on the female host showing the independence of this sex-linked pigmentary character from the endocrine milieu; the feathers themselves, although they were derivatives of the graft skin (unquestionably of male genetic composition) were, however, affected by the endocrine environment, i.e. they assumed the morphological characteristics of female plumage.

EFFECT OF EXTRINSIC FACTORS UPON FEATHER PATTERN

It has long been known that sex hormones have an effect upon the character of the pigmentation of the feathers. The unequal response of feathers to uniform hormone levels was noted by Zawadowsky (1926) and Zawadowsky and Rochlin (1927). Quantitative studies of this effect were made by Juhn and Gustavson (1930) who showed that the pigmentary threshold of reaction to female sex hormone is directly related to the growth rate of the feather. Juhn and Barnes (1931) showed that the same relationships held for the pigmentary effect of thyroxin. This work reached its culmination in the study by Lillie and Juhn (1932), who related the growth rates of the individual feather to the threshold of reaction in an excellent quantitative study. In a brief summary of this large body of work, to which only fragmentary reference has been made, it may be said that in a Brown Leghorn male or capon, injection of female sex hormone leads to the formation of a salmon-colored bar across the feathers. This bar marks the time of injection of the hormone in all growing or regenerating feathers by changing the color of the melanin deposited in the rachis, barbs, and barbules. Thyroxin has an opposite effect, i.e. leads to the deposition of black granules.

The similarity of barring produced by hormone injection to that occurring naturally suggests that the underlying factors may be analogous. Danforth and Foster (1929) found that Barred Rock skin transplanted immediately after hatching produced barred feathers and concluded that barring is a function of follicular activity. Montalenti (1934) made a study of growth rate and pattern in the Barred Plymouth Rock. He found that the width of the double bar (black plus white) was closely related to the growth rate of the feather, i.e. the higher the growth rate the wider the double bar. The ratio between growth in length and the width of the double bar was fairly close to 1.8:1 for all feathers. Such a result is to be expected if the rhythmic factors responsible for barring occupy approximately equal intervals in the various follicles. Montalenti noted that there was a high degree of synchrony of pigmentary phase among the various feathers but that this fell short of perfection, as was shown by the fact that some were in white phases while others were in black. On the basis of this and other evidence he concluded that "the barring is due to a genetic factor, working directly, and to a certain extent independently in the single follicle, and not by means of some endocrine intermediary."

Willier (1941) has applied these concepts of threshold and growth rate to the explanation of the barred patterns produced in White Leghorn and New Hampshire Red feathers by transplanted Barred Rock melanophores. His conclusions are best stated in his own words (1941, pp. 142–143):

> Applying this principle to the action of the barred melanophores in a foreign host feather we note some significant results. In a rapidly growing host feather such as the flight feathers the amount of white is greatly reduced, thus forming patterns resembling but not identical with Barred Rock control flight feathers. Measurements of the rate of growth in length of the fourth and fifth primaries show, however, that these feathers are growing much more rapidly in the White Leghorn host than in the Barred Rock controls (see Fig. 1, Willier and Rawles, 1940). The barred pattern formed in the White Leghorn feather is consequently different from that produced in a control Barred Rock feather. In some of the primaries it is almost uniformly black, only traces of white being found. When the growth rate is lower as in the breast feather the white phase is longer and the black phase is shorter.
>
> In the N. H. Red host, where the rate of growth of many of the flight feathers is somewhat intermediate between that characteristic of corresponding feathers of a White Leghorn and Barred Rock, still different barred patterns are produced. By comparing the seventh and eighth secondaries in these birds it is found that in the White Leghorn feather the alternating dark and light bands are scarcely visible at all except in the shaft; in the N. H. Red feather they are only distinct at the tip of the vane and shaft, whereas in the Barred Rock control they are more or less evident throughout the vane but much more pronounced at its apex and base. In general, the pattern produced in the N. H. Red feather resembles more closely that of the Barred Rock control than it does that formed in the White Leghorn feather. Apparently the rate of growth of the feather germ of the N. H. Red approximates more closely that of the Barred Rock than it does that of the White Leghorn.

It is scarcely necessary to point out the respects in which this work is in harmony with the conclusions about barring derived from the other approaches mentioned above. It appears as though the inherent rhythm of the follicle, even in birds which normally do not show barring, is capable of inhibiting Barred Rock melanophore differentiation periodically. Further, the relation between growth rate and barring is confirmed. Barring of this kind is thus seen to be due, in all likelihood, to the specific genetic character of the melanophore which in turn reacts to some periodic fluctuation in the follicle.

PIGMENT CELLS IN TISSUE CULTURE: DIFFERENTIATION AND RESPONSE TO HORMONES

Koller (1929) explanted mesenchyme from three- to five-day White and Black Leghorn embryos. The pigment cells are at first similar to fibroblasts and only become clearly marked off from them by the development of fine colorless granules in the cytoplasm. These granules gradually became colored, passing from pale yellow to brown as the cells develop pseudopodia. Koller found that in medium prepared from white or black embryos after removal of the eyes, the explanted cells of the Black Leghorn became pigmented as described above, but that branched pigment cells failed to develop in explants derived from the White Leghorn in either type of medium. Dorris (1936) described the general differentiation in culture in similar terms and failed to find pigment cells in cultures of Rhode Island Red or White Plymouth Rock neural crest. However, in more extensive observations, Dorris (1938) found that Rhode Island Red cultures produced melanophores, but White Plymouth Rock explants produced "no significant amount of pigment." In contrast to Koller, she obtained a high percentage of pigment cell differentiation in explants of the White Leghorn neural crest.

Hamilton (1940) confirmed the observations of Koller and of Dorris on the process of differentiation of the pigment cells and, in addition, noted that the character of the pigment granules or rods was type specific (*v.s.*). Hamilton was successful in obtaining melanophore differentiation in culture from a number of dark breeds of fowl, including New Hampshire Red, and some other bird species and from all white fowls tested, White Silkie, White Leghorn, F_1 hybrid (B.R. ♀ × W.L. ♂), White Wyandotte and White Plymouth Rock. In view of these observations no special conclusions can be based on the negative results found by Koller and by Dorris. The differential viability of the pigment cells of various breeds is discussed in an earlier section of this paper.

The influence of hormones on pigment cell differentiation in culture was tested by Hamilton (1940) who found that red breeds differentiated black melanophores, but few or no "red" melanophores, in ordinary cultures. However, the addition of sex hormones to the culture medium brings about the appearance of large numbers of red cells. Further studies of this sort by Hamilton (1941) showed that testosterone and estradiol greatly increased the numbers of red melanophores and simultaneously reduced the numbers of black melanophores in cultures derived from Rhode Island and New Hampshire Red breeds. The hormone of the adrenal cortex (desoxycorticosterone) inhibited the development of melanin in explants derived from Barred Rock embryos. This latter effect should be received with caution since it is in essence a negative one and may as logically be ascribed to some non-specific noxious property of the substance on the culture as to a specific action on the process of melanin formation.

The occurrence of two cell types, red and black, in the feathers of certain breeds and in cultures in response to hormones means that at some time the precursor melanophores must become determined in the one or the other direction. This problem of differentiation has been discussed by Willier and Rawles (1940), Hamilton (1941), and Willier (1942). These authors are in agreement in regarding it as probable that this segregation does not take place until fairly late in the life of the melanoblast, that is, not until after it enters the feather germ. It is significant that transitional stages between red and black cells do not occur in tissue culture (Hamilton) nor in mosaic feathers obtained by skin grafting (Danforth, 1937).

The attempt to make an analogy between the observed dependence of red melanophores on sex hormones or sterols in tissue culture to the normal conditions of their differentiation meets with this difficulty: red or yellow melanophores differentiate in castrated birds, that is, in the absence of the sex hormones. According to Goodale (1916, p. 27) among others "... the plumage of capons when properly cared for is fully as brilliant as that of normal males." He reports that the coloration of the Rhode Island Red, one of the breeds used by Hamilton, is not essentially modified by castration (p. 30).

Another indication that hormone level is not the only factor in controlling the type of pigment cell differentiation is made apparent by the fact that local pigmentary differences exist within and between different feather tracts in bi- or multicolored birds. These differences may in part be accounted for by differences in growth rate of various feathers and the associated differences in the thresholds of response of the precursor melanophores (*v.s.*).

An introduction to the extensive literature on the effect of hormones on pigmentation, which has been treated only lightly here, may be found in the reviews by Danforth (1939b, 1942) and by Willier (1942a). The analysis of feather development has been reviewed by Lillie (1942) and in the latest of a series of papers by Lillie and Wang (1943).

DISCUSSION AND EXTENSION

That the pigment cells of amphibians and birds originate from the neural crest is no longer a question. Our direct knowledge of a similar origin in other classes remains scanty. It will, however, be recalled that the first description linking pigment cells to the neural crest was advanced for teleosts (see Part I of this review) although other views of their origin in this group are current (see for example, Stockard, 1915). Comparative grounds alone make the assumption likely that vertebrate pigment cells have a common embryological origin (cf. Weidenreich, 1912), even though no decisive evidence is available for the cyclostomes and reptiles. A beginning has been made in the effort to discover whether or not the mammals conform to the amphibians and birds by the transplantation of the ectoderm and underlying mesoderm of mouse embryos to the coelomic cavity of 60- to 70-hour White Leghorn embryos (Rawles, 1940b). Hairs and mouse melanophores differentiated in the grafts and, in some instances, the latter spread out into the host tissues. Like the similar experiments using ectoderm or ectoderm and mesenchyme of chick embryos this gives no criterion of the embryonic origin of the melanophores, but offers a promising first step in the analysis.

The possibility that the pigment cells of all vertebrates may originate from the embryonic neural crest suggests a survey of other evidences of fundamental similarity. Is the remarkable relation between the melanophores and the epidermal cells of the developing feather unique? Or do melanophores in other classes of vertebrates also transfer pigment granules to epidermal cells? Quite recently Willier (1942b) has suggested that melanophores in mammals may supply pigment to the epidermal cells of the hairs. Riehl (1884) was the first to describe such a process in the hair bulb in human skin of newborns and adults. His description of the relations of melanophores to epidermal cells in man may be freely translated as follows (p. 37):

> In following the processes of pigment cells one frequently finds some whose boundaries are sharply outlined next to the cell bodies where they lie in contact with the pale epithelial cells, while their endings are either obscurely indicated by a pale line (*Saum*) or are entirely indistinguishable; in the vicinity of such processes diffuse yellow brown coloration and pigment granules invariably occur in greater or lesser number in the protoplasm of the cells of the hair sheath and often such granules are accumulated only on the side of the cell adjacent to the processes, so that one forms the impression that it is as though the processes had dissolved and had been taken up by the epithelial cells.

This interpretation received the support of Aeby (1885), Ehrmann (1885) *et seq.*, Kölliker (1887), and Karg (1888) among others. Aeby put this in the broadest terms: that in no vertebrate was the epidermis capable of forming pigment but that it always received granules from the chromatophores. Unfortunately only a brief publication of his results is available. Ehrmann (*loc. cit.*) convincingly illustrated similar relationships in the hair bulbs and ordinary epidermis of various mammals including man and, in addition, described and figured amphibian dermal chromatophores which appeared to be transferring pigment to the epidermal cells. In observing freshly removed skin of the frog under the microscope he was able to see (in translation, p. 516) "... a distinct streaming of pigment within the cells (i.e. dermal pigment cells) and a transfer of pigment into the overlying epidermal cells." Karg (*loc. cit.*) found dermal pigment cells in normal Negro skin which sent fine processes directly into the epidermal cells and there, according to his interpretation, supplied pigment to them. He also thought that histological sections indicated that white skin transplanted to Negroes became pigmented by a similar process.

These interpretations have been abandoned in recent years and have been replaced by the view that the epidermal cells of mammals produce their own pigment and that the dendritic cells (i.e. pigment cells) play no part in this process (see the review by Biedermann, 1928b). However, it is perhaps not too much to hope that fresh investigations on the basis of our present knowledge may confirm the older concepts and lead us to a unified view of vertebrate pigmentation to replace the confusion of hypotheses of the past sixty years.

To attain such a unified concept it would be necessary to show that the specialized pigment cells of all vertebrates have a common origin in the neural crest and, further, that the pigment cells transfer their granules to the epidermal cells not only in birds but also in some if not all of the other classes.

SUMMARY

The conclusive evidence in support of the neural crest theory of pigment cell origin in birds is discussed.

The experiments which reveal the migratory properties, and the special activities of the melanophores in pigmenting the cells of the feathers are considered along with the evidence bearing on the interrelationship between pigment cells, growth rate of the feathers, and hormones in the production of color pattern.

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HORMONES IN THE CRUSTACEA

THEIR SOURCES AND ACTIVITIES (*Concluded*)

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B. Control of retinal pigment migration

THE compound eyes of crustaceans, just as the visual organs found within many other groups of animals, possess pigments which are important in the physical adaptation of the retinal elements to light intensity. Parker (1932) has prepared an excellent review of all the literature dealing with the movements of these retinal pigments in animals. The greater part of this review is devoted to the arthropod compound eye.

Since by far the most of our information upon the hormonal control of retinal pigment migration concerns the complex compound eye of higher crustaceans, our brief introductory description of the pigments and their movements will pertain to this type.

1. The eye pigments and their movements

In an ommatidium of such an eye are three groups of pigment cells. The first contains the distal retinal pigment cells. Two of these cells appear to surround the distal portion of each ommatidium as would a collar. These cells contain melanin granules, hence their pigmented portions are black. The second group contains the proximal pigment cells. These are the retinular cells of the eye. There are characteristically eight in each ommatidium. The rhabdome comprises the differentiated inner surfaces (rhabdomeres) of these cells. The proximal ends of these cells project through the basement membrane and extensions of these form the retinal nerve fibers passing towards the optic ganglia. The pigment of the proximal cells is also melanin. The third cell group contains the reflecting pigment cells. These cells surround the eight pigmented retinular cells and may similarly extend through the basement membrane. These cells contain a pigment which is white by reflected light. The pigment is generally considered to be particulate guanin. These reflecting cells, collectively, comprise the tapetum of the eye.

Characteristically, in maximum light adaptation of the eye, the distal retinal pigment moves proximally towards the pigmented retinular cells and the proximal retinal pigment moves distally in the retinular cells to that portion of them lying distal to the basement membrane. Meanwhile, the reflecting pigment typically moves proximally to assume a position commonly proximal to the basement membrane. In this position the sensory elements of the eye, the rhabdomes, are fairly well masked by light absorbing pigment and only that light which passes through the dioptric apparatus of an ommatidium reaches the rhabdome of that ommatidium. Such a functioning eye is usually referred to as an apposition eye. This eye, it is seen, gives the maximum of definition at the expense of brightness.

In extreme dark adaptation of the eye, on the other hand, the distal retinal pigment moves distally until it surrounds only the distal region of the dioptric apparatus, and the proximal retinal pigment moves proximally until it usually comes to lie entirely proximal to the basement membrane. The reflecting pigment moves distally and surrounds the retinular cells at the level of the rhabdome. With the pigments arranged in this fashion, light striking any particular rhabdome may have entered the eye through any of a number of neighboring ommatidia. This functioning eye is known as a superposition one. Definition is sacrificed to permit greater light admittance. The reflecting pigment enables the eye to use still more efficiently the light which enters it through reflecting this light back over the sensory endings.

2. The hormonal control of retinal pigments

The earlier attempts to determine the controlling mechanism of the movements of the retinal pigments included experimental procedures designed to ascertain whether the two eyes were independent of one another in their responses to light and darkness. Parker (1897) and Castle (1927) using the shrimp, *Palaemonetes*, were able by covering one eye to have simultaneously one eye light while the other was dark-adapted. They, therefore, concluded that the pigment cells behaved as independent effectors. Employing *Palaemon* for similar experiments, Von Frisch (1908) could get no conclusive results. On the other hand, Bennitt (1924) using *Cambarus limosus* and later (1932a) working with *Cambarus virilis*, *C. clarkii*, *Libinia emarginata*, *Cancer borealis*, *Carcinides maenas*, *Homarus americanus*, *Palaemonetes vulgaris*, and *P. exilipes*, found a definite partial interdependence of the two eyes of an individual. When one eye was exposed to light and the other eye was carefully covered to exclude light, the covered eye was usually also light-adapted and almost never was more than partially dark-adapted. The very small percentage of exceptions (one case with *Cambarus* and two instances with *Libinia*) appeared to be within the normal individual variation. In view of the apparent lack of innervation of the distal retinal pigment cells, and the unlikelihood that the afferent nerve fibers of the proximal pigment cells would operate in the control of movement of this latter pigment, Bennitt suggested the possibility of hormonal control of the pigments to account for the observed interrelationship of the two eyes, although he was fully aware that possibility of nervous control was not eliminated.

Welsh (1930a) described for the fresh-water shrimp, *Macrobrachium olfersi* and *M. acanthurus*, a diurnal rhythm in the movement of their distal retinal pigment. This rhythm persisted in constant illumination. The pigment assumed the condition of dark adaptation about 6 p. m. and returned to the condition of light adaptation at approximately 5 a. m. Neither the reflecting nor the proximal retinal pigments showed any such change. Bennitt (1932b) reported a diurnal rhythm of activity of a pigment in the retina of *Cambarus virilis*. This latter rhythm differed from the one described by Welsh for *Macrobrachium* in two respects: it continued only in constant darkness and involved the proximal retinal pigment. The description of comparable diurnal rhythms in retinal pigments of other crustaceans followed quickly one upon another. Table 1 includes these.

These diurnal rhythms of retinal pigments in constant light or in constant darkness indicated beyond any doubt that the control of these movements included something other than direct response to light. As with the observations upon the interrelationship of the two eyes, however, it did not in itself distinguish between nervous or hormonal control of these movements.

In an attempt to determine whether the control of movement of the distal retinal pigment of *Macrobrachium* was nervous or hormonal, Welsh (1930a) ligated the eyestalks and found that when the ligation cut off the blood supply to the eye, the distal retinal pigment was unable to move into the distal or dark-adapted condition. He interpreted this observation to mean that there was a direct blood control of this distal retinal pigment. He considered as eliminated the possibility of the results being due to interruption of the passage of impulses in the optic nerve in this case on the ground that nerve supply to the distal pigment cells never had been demonstrated. It is interesting to recall in this connection the reports of certain earlier workers such as Von Frisch (1908), Demoll (1911), Bennitt (1924), and Bennitt and Merrick (1932) that anesthesia, oxygen lack, death, or isolation of the eyes from the remainder of the body always resulted in a condition of light adaptation of the eye.

More definitely suggestive of endocrine control of a retinal pigment were the results obtained by Welsh (1930b) in which a dark-adapted *Palaemonetes* was subjected to light for 20 minutes and then returned to darkness for the following 20 minutes. During this latter period in darkness the distal retinal pigment continued to move in the direction of light adaptation. This was interpreted by Welsh to be the result of the accumulation of a pigment-influencing substance produced by the action of light on the eye, this substance disappearing slowly in the animal in darkness.

Although the preceding work was definitely leading towards the demonstration of hormonal control of retinal pigment migration, yet the evidence for such could be hardly described as more than suggestive.

Kleinholz (1934, 1936) brought forth the first clear indication that the distal retinal pigment and the white reflecting pigment of the eyes of *Palaemonetes* are influenced by a hormonal substance. Kleinholz found that when he injected unboiled extract of eyestalks of *Palaemonetes* (equivalent to extract of 1–3 stalks) into dark-adapted *Palaemonetes* left in the dark, these animals would almost immediately begin to become light-adapted and the rate of light adaptation was quite comparable to the rate observed in the transfer of a dark-adapted animal to a lighted environment. Injections of sea water, cold-blooded Ringer's solution, or muscle extract failed to do likewise. Furthermore he found that the eyestalks removed from light-adapted animals were approximately twice as effective in producing this response as were eyestalks removed from dark-adapted animals. This last was the only direct indication that the substance in the eyestalk extract was the normal source of the retinal-pigment-activating material. Injections of similar eyestalk extracts into light-adapted *Palaemonetes* produced no significant response. There was, however, one difference between the light-adapted eyes induced by injection of eyestalk extract and those produced by normal exposure of the animal to light. In the injected animal only the distal and reflecting pigments responded to the eyestalk extract; the proximal retinal pigment was not affected in the slightest.

Kleinholz proceeded to examine the eyestalks of other crustaceans for the presence of the principle bringing about proximal movement of the distal and reflecting eye pigment of *Palaemonetes*. Unboiled extracts of light-adapted eyestalks of *Cancer irroratus* (10 stalks/.8 c.c.), *Libinia dubia* (10 stalks/1 c.c.), *Carcinides maenas* (8 stalks 1 c.c.), and *Callinectes sapidus* (5 stalks/1 c.c.) were tested for their effects upon the distal retinal pigment of dark-adapted *Palaemonetes*. From 0.01 to 0.04 c.c. was injected into each animal. Animals were killed between 31 and 38 minutes after injection. The average position (in micra) of the distal pigment in injected and control animals for each eyestalk source is seen in Table 2.

TABLE 1

Studies on diurnally rhythmic movements of retinal pigments

SPECIES	PIGMENT INVOLVED	EXTERNAL ENVIRONMENT	INVESTIGATOR	
Macrobrachium olfersi	Distal	Light	Welsh	1930a
Macrobrachium acanthurus	Distal	Light	Welsh	1930a
Cambarus virilis	Proximal	Dark	Bennitt	1932b
Latreutes fucorum	*Reflecting*, proximal		Welsh	1935
Leander tenuicornis	Reflecting		Welsh	1935
Leander affinis	*Reflecting*, distal	Light, dark	Welsh	1935
Penaeopsis goodei	Proximal	Dark	Welsh	1935
Anchistioides antiguensis	Distal	Dark	Welsh	1936
Eusicyonia sp.	Distal	Light	Kleinholz	1937b
Trachypeneopus mobilispinis	Distal	Light	Kleinholz	1937b
Parthenope serrata	Distal, proximal	Light, dark	Kleinholz	1937b
Portunus anceps	Distal, proximal	Light, dark	Kleinholz	1937b
Portunus depressifrons	Distal, proximal	Light, dark	Kleinholz	1937b
Calappa flammea	Distal, proximal	Light, dark	Kleinholz	1937b
Hippolyte pleurocantha	Distal		Kleinholz	1938
Cambarus bartoni	Proximal, distal	Dark	Welsh	1941

TABLE 2

Influence of eyestalk extracts upon the position of the distal retinal pigment in dark-adapted Palaemonetes

(*Kleinholz, 1936*)

EYESTALK SOURCE	NUMBER OF EYES MEASURED		AV. POSITION OF PIGMENT	
	Injected	Control	Injected	Control
Cancer irroratus	91	16	265.0	85.0
Libinia dubia	84	20	335.7	81.8
Uca pugilator	58	26	247.2	88.3
Callinectes sapidus	106	18	102.8	79.2
Palaemonetes vulgaris (light)	60	14	245.7	57.8
Palaemonetes vulgaris (dark)	70	18	149.5	78.3
Carcinides maenas	56	19	205.1	79.3

Only *Callinectes* eyestalks failed to give a strong positive response. The reason for this was not evident. Kleinholz believed that either his extracts were not sufficiently concentrated, or *Callinectes* lacked the specific principle in question.

The action of eyestalk extract upon the movement of retinal pigments was confirmed by Welsh (1939a). Welsh found that boiled extracts of crayfish eyestalks, when the equivalent of from one-quarter to one eyestalk was injected into dark-adapted *Cambarus*, resulted in a movement of the distal retinal pigment to a position of light adaptation and when injected into light-adapted ones resulted in more extreme light adaptation. Injection of a stronger eyestalk extract, on the other hand, the equivalent of approximately two eyestalks, resulted in a migration of both the distal and proximal pigments to conditions of light adaptation. Welsh concluded that both of these pigments are thus activated by an eyestalk hormone, but that the distal retinal pigment cells show a lower threshold of response than do the proximal pigment cells.

Welsh (1941) attempted a localization of the source of the retinal-pigment-influencing hormone of the eyestalk. Extracts of the sinus gland by itself resulted in the strongest reaction of the retinal pigments. Extracts of the medulla terminalis of the eyestalk, however, gave a considerable reaction which was attributed by Welsh to the fact that the sinus gland may extend proximally in the stalk to this ganglion, and also to the possibility that hormone had escaped from the sinus gland during its removal from the stalk. Extracts of the brain gave little or no pigmentary response. Upon these grounds Welsh concluded that the sinus gland was definitely the source of the material in the eyestalk which resulted in a movement of the distal and proximal retinal pigments of *Cambarus* to a position of light-adaptation.

It can now be concluded with a reasonable degree of assurance that a principle liberated from the sinus gland influences the state of certain retinal pigments. In the case of the crayfish, *Cambarus*, this principle acts to move the distal and proximal retinal pigments into the state characteristic for light adaptation. It seems reasonable to assume that the principle from the eyestalks of *Palaemonetes* effective in moving its own distal and reflecting retinal pigments also towards light adaptation, and the eyestalk principles of *Cancer*, *Libinia*, *Uca*, and *Carcinides* doing likewise are also products of the sinus gland.

3. Upon the number, properties, and secretion of hormones involved

Nothing, other than the fact that they are water-soluble and stable in boiling water, is known of the properties of the retinal-pigment-influencing material. It would appear reasonable to establish the hypothesis that an animal possessed a single principle concerned with light adaptation of the eye since there is no known occasion for, and apparently no described instance of, the different retinal pigments exercising any degree of independence of one another in their movements. Yet, if there is a single hormonal substance concerned with light adaptation of the eye we have still to explain the great variations found in comparing the diurnally rhythmic movements in the eyes of various crustacean species (Table 1). In some, only the distal pigment shows this activity significantly (*Macrobrachium*—Welsh, 1930a; *Anchistioides*—Welsh, 1936; *Eusicyonia*, *Trachypeneopsis*—Kleinholz, 1937b, and *Hippolyte pleurocantha*—Kleinholz, 1938), in certain others, only the proximal (*Cambarus virilis*—Bennitt, 1932b; *Penaeopsis goodei*—Welsh, 1935), in others only the reflecting pigment (*Leander tenuicornis*—Welsh, 1935), in others the reflecting and proximal (*Latreutes fucorum*—Welsh, 1935), and finally in still others the proximal and distal (*Parthenope*, *Portunus*, *Calappa*—Kleinholz, 1937b; *Cambarus bartoni*—Welsh, 1941). Any attempt to explain all these observations in terms of constant and uniform relative sensitiveness of the three retinal pigments to a single hormone obviously is impossible. Neglecting the rhythm described only in the proximal pigment by Bennitt (1932b) for *Cambarus* (since he did not observe simultaneously the distal) and that described only in those cells of *Peneopsis* by Welsh (1935) (since the other pigments appear normally to show no movement) nearly all of the remainder of the cases could be explained in terms of the finding of Welsh (1939a) that the distal pigment cells have a lower threshold than the proximal ones. Judging from the eyestalk-extract injection results obtained by Kleinholz (1936) for *Palaemonetes* and the rhythm found in *Leander affinis* involving only the distal and reflecting pigments, one might tentatively postulate that the threshold for the reflecting pigment lay between that for the distal and the proximal pigments. That this assumption of a single hormone with the threshold of the pigments ranging in all species in the order distal<reflecting<proximal is unsound is then to be seen in that only the reflecting pigment of *Leander tenuicornis* and the reflecting and proximal pigments of *Latreutes fucorum* show the diurnal rhythm under constant conditions of light,

although all three pigments show response normally to changes in light intensity. We still have far too little information with regard to reciprocal injection experiments to conclude whether (a) more than one retinal-pigment-influencing hormone is present among the species of higher crustaceans; (b) the thresholds of the three retinal pigments vary relative to one another in the different species; or (c) that both situations are to be found.

Another factor which, with little question, must also be taken into careful consideration is the direct influence of light upon the pigment cells. This might act either by modifying the threshold of the pigment cells to the hormonal stimulus or might induce an independent response of certain of these elements. Evidence that some such factors are at work is to be found in such experiments as the following: Bennitt (1924), working on *Talorchestia*, found that the eyes of an animal decapitated immediately behind the brain, continued to show responses to light and to dark though circulation of body fluids was out of the question. Parker (1897), Castle (1927), and Bennitt (1924, 1932a) showed more or less dark adaptation of the covered eye of an animal whose other eye was exposed to and fully adapted to light. Kleinholz and Knowles (1938) showed differential response over a single eye when the shrimp, *Leander*, was placed upon a black background.

Not precluded by any means is also the possibility that dark adaptation is brought about by a second and antagonistic hormone formed either in the eyestalks or in some other organ of the body. The three pigments might also show difference in thresholds to this second hormone. In support of this concept of dual control by two antagonistic mechanisms is the increasing realization that there is no resting state of many pigment cells beyond that in which the contained pigments are not migrating (Parker, 1935). Increasing the complication of the problem is also the possibility of two or more independent mechanisms performing parallel functions.

Thus, it is definitely true that even though the sinus gland liberates a retinal-pigment-affecting principle, we are far from a complete explanation of the control of physical adaptation of the crustacean eye to light intensity.

Assuming, upon quite good grounds, that the rhythmic formation and liberation of a hormone by the crayfish sinus gland was of major importance in determining the diurnally rhythmic retinal pigment migrations under constant conditions, Welsh (1941) speculated that the liberation of the principle in question was controlled by an inhibitory nerve. The conception was supported by the fact that a wide variety of factors such as low temperature (Congdon, 1907; Welsh, 1941), O_2-deficiency (Bennitt and Merrick, 1932), anaesthesia (Bennitt, 1924; Welsh, 1930a, 1941), and death (Bennitt, 1924, 1932b) which depress nervous activity result in light adaptation of the eye. It is not yet certain, however, that light adaptation under all these circumstances is the result of a specific hormone, since isolation of the eye from the remainder of the body may result in the same thing (Bennitt, 1924). However, if Welsh's assumption is correct, then during the day phase of the diurnal cycle in constant darkness the retina would become light-adapted as a result of an inhibition of inhibition, and in normal response of the pigments to light, the stimulation of the retina would result similarly by inhibition of an inhibitory sinus gland nerve.

C. Control of molting and associated changes

As do a number of other groups of organisms whose body is encased in a hard or tough exoskeleton, the crustaceans grow discontinuously by a series of molts. The molting process is by no means simple. It involves in the great majority of higher crustaceans radical changes in calcium metabolism within the body. For some time prior to molt, calcium is resorbed from the exoskeleton and stored within organs such as gastroliths (Huxley, 1906; Robertson, 1941) or the hepatopancreas (Paul and Sharpe, 1916; Robertson, 1937). Immediately following the shedding of the old cuticle, the new cuticle is hardened by the redeposition of the stored calcium and the addition of newly absorbed calcium (Hecht, 1914; Paul and Sharpe, 1916; Maluf, 1940; Kleinholz and Bourquin, 1941b). Another change associated with normal molting of the crustaceans is a gradual increase in the rate of oxygen consumption commencing a week or more before the molt, reaching a peak during the actual shedding process and then a gradual decrease during the following week (Scudamore, 1941a). Still another change intimately related to molting is increase in size by water absorption. Such a change in water content involving an increase in size of an animal about to molt has been reported by Paul and Sharpe (1916), Olmsted and Baumberger (1923), Baumberger and

Olmsted (1928), Robertson (1937), Drach (1939), and Scudamore (1942). This increase in water content which commences a few days before shedding the exoskeleton and reaches a maximum at about the time of molt is responsible for the total immediate growth of the organisms.

In a discussion of the control of molt in crustaceans we must take into account the possibility that all of these changes may be intimately bound up with one another in a unified mechanism.

Megušar (1912) was the first to describe an acceleration of molting following upon removal of eyestalks. Megušar noticed that the first molt and also succeeding molts took place earlier in specimens of *Astacus vulgaris* from which eyestalks had been removed than in normal animals. Abramowitz and Abramowitz (1938) working with *Uca pugilator* stated that "blinded crabs molt frequently (perhaps more frequently than normal specimens according to our impression)." Hanström (1939) reported that eyestalkless *Eriocheir sinensis* molted earlier than normal animals. Similar reductions in the times to the first and subsequent molts of eyestalkless animals were reported for *Cambarus immunis* by Brown and Cunningham (1939), for *Uca pugilator* by Abramowitz and Abramowitz (1940) and Kleinholz and Bourquin (1941a), and for *Cambarus clarkii* by Smith (1940). Brown and Cunningham were dealing with adult *Cambarus* whose normal molts occur twice a year, one in April or May and the other in July or August (Van Deventer, 1937; Tack, 1941; Scudamore, 1942). Since their observations were made largely during the spring the normal controls also molted but after a significantly longer interval on the average than in the case of the eyestalkless ones. Smith, on the other hand, experimented with very young crayfishes which during their first season molt a number of times. He was able to show that the intermolt period for eyestalkless individuals was, on the average, only about two-thirds that for normal ones.

All of these observations pertained primarily to the actual shedding of the partially resorbed exoskeleton. These results indicating an increased rate of molting (or a decreased intermolt period) following removal of the eyestalks could, of course, be interpreted as due to one of three possibilities: (a) the removal of influential nervous structures within the optic stalk; (b) the effects of general operative injury upon the body; or (c) the removal of an eyestalk source of a molt inhibiting hormone. Kleinholz and Bourquin (1941a), with no supporting evidence, leaned toward the first of these three possible interpretations. Darby (1938) had reported that injury to *Crangon armillatus* resulted in an earlier molt than seen for normal animals. Smith (1940), however, demonstrated that the accelerated molt resulting from eyestalk removal in *Cambarus* was not the result of injury alone inasmuch as operative removal of other appendages such as the antennae resulted in no such acceleration. Furthermore, removal of the retina from the eyestalk, which there was good reason to believe was a more severe injury to the animal than removal of the eyestalks at their base, resulted in a *retardation* of molting rate.

The first clear evidence indicating that the acceleration of molting followed removal of the eyestalks was the result of removal of the source of a molt-inhibiting hormone was put forth by Brown and Cunningham (1939). These investigators found that removal of the eyestalks from adult *Cambarus immunis* resulted in an early molt in the operated animals, and that an implant of sinus gland into the ventral abdominal sinus of such eyestalkless animals resulted in a postponement of molt even to a time after that of the unoperated control animals. Further research by these investigators indicated that whereas sinus gland implants would more than prevent the usual accelerated molting rate in eyestalkless individuals, implantations of eyestalk tissue from which the sinus gland had been removed were less than one-fifth as effective. Animals from which one eye was removed molted only very slightly more frequently than the normal controls. These results were not reasonably interpretable on any basis other than a hormonal one.

Unfortunately, the later excellent works of Abramowitz and Abramowitz (1940), Smith (1940), and Kleinholz and Bourquin (1941a) did not include any eyestalk extract injection or gland implantation experiments to confirm the hormonal interpretation of these results of eyestalk removal. However, on the basis of the work of Brown and Cunningham, both Abramowitz and Abramowitz and Smith agreed that the most logical interpretation of their results was a hormonal one.

Striking confirmation for a hormonal inhibition of molt by action of the sinus glands came in the work of Kyer (1942) and later of Scudamore (1942). These two investigators discovered independently that when the eyestalks of crayfishes are removed during a non-molting period such as between September and March, the eyestalkless animals immediately proceed to deposit calcium in the form of gastroliths in the wall of the stomach. At room temperature, the gastroliths begin to form about 24 hours following the eyestalk removal and to increase slowly in size over eight or ten days. Thereafter, they increase at a rapidly accelerating rate up to about the fifteenth or twentieth day when the animals usually molt. Both investigators found that the formation of the gastroliths in eyestalkless animals could be entirely prevented by periodic implantation of sinus glands into the abdominal region of the animal. Scudamore found that after the periodic implantation of sinus glands (at three- or four-day intervals) ceased, gastroliths would begin to form after the last implant had ceased to be viable. Such gastroliths continued to increase in size up to the time of molt. Implantation of stalk tissue from which the sinus glands had been carefully removed did not inhibit gastrolith formation in the slightest.

Confirmation of the inhibiting action of the sinus gland upon molting proper and upon gastrolith formation was given by Brown (1942) who devised a method for removing the sinus gland from the crayfish without significantly disturbing other eyestalk structures or vision. Such animals with only the sinus glands extirpated showed both the induced gastrolith production and molt. Very recently Pyle (1943) has described a change in the relative abundance of acidophylic and basophylic granules in the sinus gland correlated with the molt cycle of *Cambarus* with acidophylic granules greatly predominant just prior to molt and basophylic ones, after molt completion.

Scudamore (1942) investigated the matter of possible hormonal control of other changes associated with normal molting. He found that removal of the eyestalks with their included sinus glands resulted in a greatly accelerated rate of oxygen consumption comparable to that observed in normal molt. Eyestalkless animals were observed to eat more constantly than normal animals. Following eyestalk removal there was also resorption of calcium from the exoskeleton and the gradual increase in water content of the organism as in the normal molting process. Thus these changes normally associated with molting in the crayfish are similarly seen following eyestalk removal. Scudamore found that implantation of sinus glands into eyestalkless animals would prevent all of these changes. It thus appeared that (a) they were all individually influenced by one or more sinus gland hormones or that (b) they were intimately related to one another in a single functional system and that this system was controlled by a hormonal substance from the sinus gland.

Observations of C. L. Turner on *Cambarus* (unpublished) and Hess (1941) on *Crangon*, indicating that females carrying eggs upon their pleopods do not molt until after the young have hatched, find their explanation in sinus gland action, since molting in such animals follows eyestalk removal.

Certain evidences also gave reason for suspecting that a hormonal substance originating at another point in the body was cooperating with the sinus gland material in controlling molt. The gastroliths of eyestalkless animals show evidence of a rhythmical fluctuation in the rate of its formation which was traced by Scudamore to a rapid deposition during the night and little or no deposition during the day. This diurnal rhythm in the rate of a molting activity is possibly under the control of a molt accelerating principle. Interesting in this connection was the observation that strong stimulation of the eyestubs of eyestalkless animals, or injection of brain extract, resulted in a transitory acceleration of O_2 consumption.

Koller (1930) was one of the first to describe a relationship between the eyestalks and calcium metabolism of the animal. He was led to suspect this since modifying the calcium content of the medium in which animals were contained modified the background responses of the chromatophores which were apparently controlled in good measure by an eyestalk hormone. Koller found that eyestalkless animals, upon molting, yielded cuticles containing a lower percentage of salts soluble in dilute hydrochloric acid than those cast from normal animals. This result he believed due to the absence of the eyestalk hormone. Koller attempted to check this conclusion by a comparison of the inorganic content of the cast skeletons of animals adapted to black and to white backgrounds. Upon a black background very little of the color change hormone from the eyestalk was believed to be present in the blood stream while upon white a high concentration was believed present. Koller's results in this latter experiment did not indicate any significant difference between the two lots of animals and consequently did not support the conclusion that a single hormone was influencing both chromatophores and calcium resorption from the cuticle.

The results of Koller indicating a difference in inorganic content of normal and eyestalkless animals were confirmed by Plankemann (1935). Kleinholz and Bourquin (1941b), however, found no difference in the amount of calcium in the molted exoskeletons of normal and eyestalkless *Palaemonetes*. It should be mentioned that Kleinholz and Bourquin measured only the calcium whereas both Koller and Plankemann determined the total material removed by hydrochloric acid. The results of Koller and Plankemann can best be explained in terms of molt control by an eyestalk principle rather than by a general calcium metabolism influencing principle. They could be interpreted to indicate that calcium resorption was more complete in eyestalkless animals than in normal ones. This might well be expected inasmuch as eyestalk removal would certainly dispense with all of the molt-inhibiting principle whereas under normal circumstances the molt-inhibiting principle is probably being still secreted at a very slow rate.

Growth is another process which should be considered here since it is normally associated with molting. Animals whose eyestalks have been removed grow at a considerably more rapid rate than normal animals. This was found to be true for *Uca* by Abramowitz and Abramowitz (1940). These investigators attributed the considerably larger size of eyestalkless animals at the end of their experiments to the greater frequency of molts. Smith (1940) working with young *Cambarus clarkii* (17–24 mm. from rostrum to telson) found that at 20° to 22°C the average intermolt period for normal animals was 12.12 ± 0.65 days whereas the same animals after removal of the eyestalk showed an intermolt period of 8.10 ± 0.19 days. Those crayfishes from which the eyestalks had been removed were in several cases observed to molt two or three times at this increased frequency and these animals were significantly larger than the normal animals with their longer intermolt periods and therefore fewer molts in the same period of observation.

On the basis of the results obtained thus far there seems to be no evidence pointing to a hormonal control of calcium or water metabolism, of O_2 consumption, or of growth, aside from the control of such changes as normally accompany ecdysis. All of these changes may be due to variations in quantity of a single hormone which could be called a molting or a growth hormone.

D. *Influence upon heart rate and general motor activity*

For a number of years a correlation between the state of certain chromatophores and general motor activity has been suspected. As early as 1900 Gamble and Keeble saw associated in *Hippolyte* the concentration of the red and yellow pigments and diffusion of the blue and increased motor activity and heart rate. Menke (1911) believed a comparable relationship obtained in an isopod involving the melanophores. Koller (1936) working with the amphipod, *Hyperia*, noticed that in actively swimming animals the chromatophores were expanded and in inactive individuals they were contracted. After crustacean chromatophores were shown quite definitely to be under endocrine control investigators were led to suspect that the color-change hormones were involved simultaneously in controlling motor activity.

A first experiment in this general direction was made by Welsh (1937). Exposed hearts of *Cambarus virilis* were perfused with boiled extract of eyestalks of *Palaemonetes* and of *Cambarus*. Both extracts resulted in significant heart acceleration; the effects of the *Cambarus* stalks were the greatest. An extract of muscle tissue failed to produce similar acceleration. Welsh (1939b), working with *Leander serratus* but now injecting the extracts, confirmed the heart-accelerating action of eyestalk extract and observed a simultaneous concentration of pigment within the red chromatophores. When, however, Welsh extracted dried *Leander* or *Crangon* eyestalks with absolute ethyl alcohol, this extract concentrated the red pigment completely but had no influence upon heart rate. He concluded from this observation that the heart-accelerating principle was not the chromatophorotropic one. Further experiments led him to believe that the heart-accelerating principle in his extracts was acetylcholine which he found in abundance in all the nervous tissues of the crustaceans. A large part of the contents of the eyestalks comprised, of course, central nervous ganglia. It is surprising that the alcohol-soluble fraction was ineffective upon the heart since acetylcholine is very soluble in ethyl alcohol.

The question of a heart-accelerating principle was investigated further by Scudamore (1941b) working with the shrimp, *Palaemonetes vulgaris*.

He found a coefficient of correlation of 0.91 between the degree of concentration of the red pigment and the rate of heart beat. There was no correlation between heart rate and the state of the white chromatophores. This remarkable correlation between the red pigment and heart rate obtained during adaptations to black and white backgrounds and in response to darkness. The correlation was also found in changes following upon removal of the eyestalks and injection of extracts of either whole eyestalk or of sinus glands by themselves. An absolute ethyl alcohol extract of *Carcinus* sinus glands also simultaneously concentrated the red pigment and accelerated greatly the heart rate of *Palaemonetes*, contrary to the results obtained by Welsh (1939b) on *Leander*.

It thus appears that a principle from the crustacean sinus gland acts as a heart accelerant. Since under normal conditions of background adaptation and response to light and darkness, the high correlation of red pigment state and heart rate obtained, it appeared very probable that a single hormone is normally involved in these two functions. It was not determined whether the sinus gland principle operated directly or indirectly to accelerate the heart rhythm. Acetylcholine and nerve cord extracts accelerated heart beat but, in the concentrations used, they showed no significant action upon the red chromatophores.

Kalmus (1938b) and Roberts (1941) have observed a persistent diurnal rhythm of motor activity of crayfishes in constant darkness. Activity of both *Potamobius astacus* and *Cambarus virilis* which were investigated was found to increase during the night hours. Both experimenters observed that removal of both the eyestalks resulted in abolishing this diurnal rhythm. Kalmus found further that injection of water or alcohol extract of eyestalks into eyestalkless animals would result in a greatly increased motor activity lasting for several hours. Injection of adrenalin, salt solution, or water gave no such increase. He concluded that the eyestalks contained the source of a hormone important in stimulating motor activity. A similar diurnal rhythm had been observed in *Potamobius* by Kalmus (1938a) for the red chromatophores.

Roberts (1941) observed a decrease in activity of *Cambarus virilis* following eyestalk-extract injection. This last would seem to be more consistent with the observations of Scudamore (1942) indicating that eyestalk-extract injection greatly depressed O_2 consumption in *Cambarus immunis*.

Schallek (1942) confirmed the loss of the diurnal rhythm of locomotor activity in *Cambarus* following eyestalk removal. Activity increased following the operation and then remained at the higher level for as long as three weeks. Sinus gland implantation or sinus-gland extract injection failed to reduce the activity. Severing of the optic nerves had the same effect on activity as eyestalk removal. Schallek concluded that the eyestalks contained an inhibitory center which influenced locomotory activity only through nerves. If this is true any hormonal influence on locomotor activity would probably be indirect, by way of such a center.

Although a number of points of difference between the results of various investigators need resolution, it would appear that the observed correlation between chromatophore state and certain motor activities has a hormonal basis. The sinus gland seems to possess a heart-accelerating principle which is also chromatophorotropic. It is not yet known whether this principle is also that one probably influencing locomotor activity, or even whether the latter is a sinus gland product.

E. Influence upon viability

Brown (1938) reported that eyestalkless *Cambarus* were unable to survive for more than a few days. Under the adverse conditions of the animals in his experiments (starvation, high temperature, and normal molting period) they survived only 5.3 ± 0.23 and 4.1 ± 0.22 days at 25°C in two experiments. Controls consisting of normal animals and ones from which a single eyestalk had been removed, survived very much longer as did also eyestalkless animals which were held at 7°C. Implantation of eyestalk tissue into eyestalkless animals yielded a significantly longer survival time, 6.3 ± 0.42 and 7.5 ± 0.81 days despite more severe operative disturbance. These results were confirmed by much more decisive data by Brown and Cunningham (1939) who went on to demonstrate beyond reasonable doubt that the sinus gland of the eyestalk was the specific source of the principle involved.

Brown (1939b) using *Palaemonetes vulgaris* found that eyestalkless animals exhibited a much higher death rate than normal controls. An implantation of a *Carcinus* sinus gland into the ventral abdominal sinus of eyestalkless animals reduced the death rate for 4 or 5 days to the level of that of the normal controls. The duration of this activity of the implant corresponded with the length of time the implant was active upon chromatophores (Brown, 1940). This experiment demonstrated that the principle in question was possessed by the brachyurans as well as the macrurans.

Smith (1940) working with very young crayfishes confirmed entirely the viability influence of the eyestalks. Under the more favorable conditions of his experiments the eyestalkless animals survived on an average of 17.1 ± 1.14 days at 9–14°C and 19.47 ± 1.48 days at 20–22°C.

Abramowitz and Abramowitz (1940) found a similarly decreased viability following eyestalk removal from *Uca pugilator*. During the 48 days of their observations 89 per cent of their eyestalkless animals died as against 16.6 per cent of the controls.

Scudamore (1942) found that under the conditions of his experiments eyestalkless adult crayfishes survived, on the average, 16.9 days while eyestalkless animals receiving a sinus gland implant every 3 to 4 days survived an average of 38.5 days. Other eyestalkless animals receiving one or few repeated gland implants survived an average of 24.8 days after the last implant, indicating that the implanted gland continued to function for about a week.

Only Kleinholz and Bourquin (1941a), who studied *Uca pugilator*, apparently failed to confirm the viability influence of the eyestalks. This was most probably due to the fact that their observations continued only 40 days. Under experimental conditions far more favorable to extending life than those of Abramowitz and Abramowitz (1940), this would appear, perhaps to be too short a period. It is also unfortunate that the temperature at which their experiments were conducted was not stated since this is unquestionably an important factor. Kleinholz and Bourquin attempted to account for the positive results obtained by others on the ground that in these other cases the animals were not given sufficient depth of water in which to molt successfully. This explanation was, of course, quite irrelevant for the work with crayfishes and with shrimp, and furthermore does not explain the observation of Abramowitz and Abramowitz that under quite similar experimental conditions 70 per cent of the eyestalkless *Uca* and only 28 per cent of the normal *Uca* died during or within one day of molt.

Since decreased viability may be due to so many different physiological causes, there arises the question as to what specific changes accounted for that in question. That question still can not be answered in any satisfactory manner. Since by far the vast majority of eyestalkless animals died during or immediately after casting their old exoskeleton, or in an incipient molt, it has been quite generally suspected that the molt-inhibiting principle might be the one also involved here. Needless to remark, normal animals usually survive many molts. Eyestalkless animals have seldom been observed to molt more than twice; a great many do not even molt once. An eyestalkless animal no sooner completes one molt than it immediately prepares for the next. This is true even in adult specimens which normally pass several months before starting a succeeding molt. It is also well known that the molt process involves tremendous changes in the whole metabolism of the body. It is highly probable that one or more of these changes are directly responsible for the early death of the operated animals. That the great majority of deaths come at the actual time of casting off the exoskeleton would appear due to the generally weakened animals having great difficulty completing that especially rigorous process. Having completed one molt, however, they stand an excellent chance of surviving until the time of the next.

A large number of eyestalkless crayfishes, especially during a non-molting season die before any visible external signs of the process are evident. This also suggests strongly that the removal of the eyestalks has resulted in some change other than induction of a normal molt.

In brief, the sinus glands appear essential to the normal continued life of the crustaceans thus far investigated. This "viability effect" may well be the result simply of *total* absence of the molt-inhibiting hormone, but the effect apparently is not to be explained solely in terms of the normal molt hazard together with the more frequent molts. It appears from the evidence at hand to be due to more fundamental metabolic disturbances resulting in the animal becoming progressively less able to undergo a successful molt. Since even periodic sinus gland implants can apparently not keep an eyestalkless animal alive indefinitely, there is a possibility that the eyestalk ganglia or even a hormone liberated from the X-organ might also have an essential vital function.

Since this review was completed, Abramowitz, Hisaw and Papandrea (1944) have found that a factor in extracts of crustacean sinus glands possesses a powerful diabetogenic action. They suggest that this factor may normally operate in the regulation of sugar metabolism in crustaceans.

F. General conclusions

Considering all the information at hand, the sinus gland of the higher crustacean evidently produces more than one hormone. Its simple structure belies its complex function. Its complex innervation, on the other hand, is more consistent with its manifold functions.

It is evident that at least three chromatophorotropic principles from the gland can be differentiated by chemical and physiological means. All crustaceans examined have definitely two such principles and since brachyurans differ from macrurans in the effects of extracts of their sinus glands upon a *Crago* black chromatophore type, a third hormone is also indicated. This conclusion of three chromatophorotropic principles is not final. All one can conclude definitely is that *no less than* three principles will account for the observed facts. Assuming the simplest picture, that of only three such principles, we still cannot decide between two possibilities: (1) that two particular principles are common to all higher crustaceans and that such macrurans as *Crago* and *Palaemonetes* have, in addition, a third one which is not to be found in such brachyurans as *Carcinus*, *Uca*, and *Libinia*, or (2) that one particular principle (relatively alcohol-soluble) is common to all crustaceans, and a second (relatively alcohol-insoluble) is different in certain brachyurans from what it is in certain macrurans.

Kleinholz (1936) considered that one hormone ("the eyestalk hormone"), through threshold differences, accounted for all the chromatophore and retinal pigment responses. Even with the facts available to him at that time this conclusion was untenable. In the first place, considering the observation that the eye is light-adapted and the dark chromatophore pigment is concentrated by eyestalk-extract injection, together with the fact that this effect is produced even when the dosage injected is unquestionably abnormally high, it is at once obvious that in order for one hormone to account for all, the retinal pigment must have a lower threshold than the body pigments to the single hormone. Under these circumstances a very low concentration of the hormone would then affect neither retinal nor chromatophore pigments; a slightly higher one would affect only retinal pigment and a still higher concentration, both pigments. This concept is quite untenable since it has long been known that the dark chromatophores of *Palaemonetes*, for instance, are more or less fully concentrated by hormonal action in darkness while the retinal pigments are in a state of complete dark adaptation.

Hanström (1937a), in full appreciation of all these facts, concluded that the retinal pigments must be controlled by a different eyestalk hormone from that concentrating the dark pigment. Kleinholz (1938), still considering the question unsettled, reported some further experiments which led him to the same conclusion already reached by Hanström and in part by Abramowitz (1937b). Among other things, Kleinholz showed that the threshold for the retinal pigments to eyestalk extract was approximately twenty times that of the body pigments.

We cannot yet conclude, however, that the retinal-pigment-affecting principle does not also have some type of effect upon integumentary chromatophores. Realization of the fact of more than one eyestalk-originating chromatophorotropic principle reopens the problem to a certain extent. The complex differential behavior of chromatophores in response to background in light leads one to suspect that several chromatophore-affecting hormones do not influence retinal pigments.

We can say very little about the identity of the agents producing other changes in the organism with the principles thus far discussed. The correlation between heart rate and red pigment state is suggestive of a single principle controlling both. The same may be said for general activity and the dark chromatophores.

Koller's practical failure to find differences in the "calcium metabolism" of black- and white-adapted *Crago*, and our own futile attempts to find accelerated molting rate in animals maintained upon a black background, do not support a hypothesis of an identity of the dark-pigment-concentrating or white-pigment-dispersing principle and the molting one.

Examining all the evidence there would appear to be at least five sinus gland principles, three chromatophorotropic ones [(1) alcohol-soluble chromatophorotropic, (2) alcohol-insoluble chromatophorotropic (*Crago*-tail affecting), (3) alcohol-insoluble chromatophorotropic (non-*Crago*-tail affecting)] certain of which influence also heart rate and motor activity, a retinal-pigment-activating one, and one concerned with inhibition of molt and associated changes.

III. THE X-ORGANS

The crustacean X-organs (Hanström, 1931, 1933, 1934a–d, 1937a, 1941; Boräng, 1933; Ståhl, 1938a, b; and Carstam, 1942) are apparently modified portions of sense organs. It is readily possible to trace these organs from the lateral frontal sense organs of branchipods such as *Artemia* and *Branchipus* which contain only bipolar sensory elements, through the Euphausiacea where the organs contain both secretory and sensory elements, to the Stomatopoda, Mysidacea, and Decapoda where there are distinct secretory organs separate from the sensory elements. In such cases the peripheral portions of the original organs persist as the sensory organ and the proximal portion has been converted into the secretory organ.

In the stalk-eyed crustaceans the X-organs are usually (exceptions include the anomurans, *Gebia*, *Emerita*, and *Hippa*) located in the stalk along with the sinus gland (usually on opposite side of stalk) and certain central nervous ganglia. In other crustaceans the X-organs are located in the head close to the brain. The X-organs have been found in almost all higher crustacean species examined (possible exceptions may include *Astacus*, *Sesarma*, *Aratus*, *Uca*).

The X-organ in typical stalk-eyed crustaceans lies inside of the neurilemma which covers the medulla terminalis and the nerve supplying the ventral eye papilla. In the Natantia, it extends along the nerve to form knots of secretory cells extending nearly to the hypodermis while in the Anomura and Brachyura it lies more proximal and against the medulla terminalis. The gland is innervated by a branch of the nerve supplying the eye papilla.

Certain inclusions of the gland cells stain deeply with eosin and acid-fuchsin (Hanström, 1939) while other masses exhibiting a concentric structure suggesting periodic additions are basophylic in reaction (Pyle, 1943). In the decapods there are usually numerous vesicles charged with a colloid throughout the gland. In the Euphausiacea the gland consists of a single vesicle whose wall comprises secretory cuboidal cells. Due to this vesicular nature of the gland, Hanström (1941) has compared it with the vertebrate thyroid.

Nothing is yet known of the normal function of the X-organ in the animal. The histological evidence definitely indicates it to be endocrine. Hanström, basing his view upon the apparent absence of the gland in a few species, speculates that its functions must be less essential than those of the sinus gland.

Injections of *Callinectes*' eyestalks from which sinus glands were removed, and of *Hippa* X-organs (together with some of brain tissue) were without effect upon *Palaemonetes* chromatophores (Hanström, 1937a). *Carcinus* eyestalks without sinus glands showed no characteristic action upon *Uca* black or *Palaemonetes* red pigments and comparison of the activity of total stalks with activity of sinus glands by themselves showed the sinus glands to be the only eyestalk tissue of seven species of crustaceans effective upon these two pigmentary types (Brown, 1940; Brown and Scudamore, 1940). Thus, all experiments conducted in an attempt to discover an X-organ function have yielded negative results.

IV. THE SCHWARZORGAN

It will be recalled that the first clear evidence for hormonal control of chromatophores in crustaceans came from blood transfusion experiments by Koller (1925, 1927), using *Crangon* (*Crago*). In these experiments Koller found that transfusion of blood from a black animal to a white one induced darkening of the latter due to dispersion of dark pigment. On the other hand, Koller could obtain no corresponding lightening of dark animals through transfusion of blood from a white individual. There seemed therefore to be evidence for a hormonal substance inducing melanin dispersion. In 1928 Koller, while confirming the concentrating action demonstrated by Perkins (1928) for the eyestalk, described a second source of a chromatophore-activating hormone in the rostral region of *Crangon* and *Leander*. This source Koller called the *Schwarzorgan* and named its principle *Expantin* as a result of its action on the dark pigment. Evidence for the activity of such a source came from injecting rostral region extracts made with black-adapted animals into white-adapted ones with consequent darkening of the latter, and by destruction of the *Schwarzorgan* by cautery whereupon the animal remained entirely pale regardless of background color or light intensity. White-adapted animals, fed rostral region, darkened, hence it was concluded that *Expantin* was resistant to the digestive enzymes. Koller believed that the *Schwarzorgan* was probably the lymph gland described in the rostral region of decapod crustaceans by Cuenot (1905) and Kollman (1908).

Although Koller's experiments appeared quite convincing and later observations (Koller, 1930) on the results of stimulation of the free ends of the optic nerves after stalk amputation appeared fully understandable only in terms of this *Schwarzorgan*, yet most other investigators were quite unable to find any such chromatophoric activity of the rostral region. Perkins and Snook (1931) and Brown (1935b) did not find such activity in *Palaemonetes;* Kropp and Perkins (1933a), Kleinholz (1938) and Carstam (1942) did not find such in *Crago* (*Crangon*); and Hanström did not find such in unboiled or boiled rostral-region extracts of *Cambarus*. Beauvallet and Veil (1934), however, using highly concentrated extracts of *Palaemon* (*Leander*) appeared to obtain a positive reaction, but Carstam (1942) using the same genus failed to confirm this.

In the light of these conflicting observations, the existence of a rostral-region source of a dark pigment dispersing hormone in macruran decapods is highly questionable. The resolution of this controversial question will perhaps be found later in studies of hormone production by central nervous organs.

V. HORMONE PRODUCTION WITHIN CENTRAL NERVOUS ORGANS

From the first demonstration of hormonal control of crustacean chromatophores, the vast majority of investigators have concluded that two or more hormones are involved. An extra-eyestalk source (rostral region) of a hormone dispersing the dark pigment appeared to Koller (1928) to be the only means of interpreting his experimental data. Koller believed, furthermore, that the source of a third hormone, his *Gelbstoff*, whose action was specific dispersion of yellow pigment, was an organ separate from the *Weissorgan* of the eyestalk and the *Schwarzorgan* of the rostral region of *Crangon*, but he performed no experiments to locate it.

Perkins (1928), in his excellent work upon *Palaemonetes*, considered the resting state of the colored chromatophores to be one of intermediate pigment dispersion. This conclusion was based upon the state finally assumed by the pigment cells in a region deprived of blood circulation. The immediate concentration or dispersion of the pigment in the region deprived of blood supply following readmittance of blood was believed due to separate hormones for pigment concentration and for pigment dispersion suddenly entering the region. Since pigment dispersion was complete in an animal whose eyestalks were amputated, it appeared obvious that the source of the "factor for expansion" had to lie outside of the eyestalks. Kleinholz (1942), in attempting to support his opinion that the evidence at hand indicated only one chromatophorotropic hormone whose action it was to concentrate colored pigments of shrimp, quite erroneously described Perkins (1928) as considering that concentration of the pigment was the result of action of a specific hormone whereas dispersion was an inherent property of the chromatophore.

Brown (1935b) demonstrated that the rapid concentration of *Palaemonetes* white pigment in response to a white background was the result of hormonal action. Nerve transection did not interfere with this response. Whereas removal of a single eyestalk very definitely reduced the subsequent rate of concentration of the red pigment in response to a white background, it did not influence in the slightest the rate of concentration of white pigment in response to a black background. This seemed to point to the extra-eyestalk source of a white pigment concentrating hormone. This hypothesis was readily confirmed by finding that injection of extract of anterior cephalothorax strongly concentrated the white pigment. Stimulation of the eyestubs of eyestalkless animals accomplished the same thing. Furthermore, it was possible to select an eyestalkless *Palaemonetes* with completely dispersed white pigment and, by stimulating the eyestubs weakly at two- to four-minute intervals with the aid of an induction coil, to obtain in fifteen to thirty minutes a complete concentration of all the white pigment of the body. The rate of concentration resembled very closely the normal response of these chromatophores to a black background. Finally one might mention the fact that in eyestalkless *Palaemonetes* white pigment may be found in all states with no apparent dependence upon light intensity or background (Brown, 1935a; Hanström, 1937a).

In 1939 Brown pointed out that the shrimp, *Crago*, must definitely possess outside of its eyestalks a source of a dark-pigment-dispersing hormone. Upon removal of the eyestalks the animals first darkened strongly and then after about an hour lightened to a condition in which the dark pigment averaged an intermediate condition. Stimulation of the stubs of the eyestalks after a suitable interval resulted in a repetition of the transitory darkening of the animal. It thus appeared that eyestub stimulation served as a heterologous stimulus to bring about the release of a melanin dispersing principle from some organ in the body outside of the eyestalks. Since the existence of Koller's *Schwarzorgan* appeared highly questionable (see Section IV), the matter of the source of this material remained, still, largely an open question.

A source of a hormone concentrating *Palaemonetes* red pigment appeared also to lie outside of the eyestalks since stimulation of the eyestubs (Brown, 1935b) resulted in a transitory concentration of this pigment. Unpublished observations have indicated that this response is very slight an hour or two following stalk removal, but gradually increases over a twenty-four-hour period. The substance in question appeared therefore to be actually produced outside of the stalks and not merely stored there after formation in the stalks as suggested by Kleinholz (1936).

Evidence for chromatophorotropic hormonal substance arising outside the eyestalks is therefore quite extensive.

The first statement that crustacean central nervous organs were the source of chromatophorotropic material came from Brown (1933) who found that injection of an extract of these organs into eyestalkless *Palaemonetes* resulted in a definite concentration of the hitherto completely refractory red pigment. This activity of the central nervous organs was independently described for *Penaeus japonicus* by Hosoi (1934) who conducted more extensive experiments. Hosoi calculated on the basis of his data that the central nervous organs showed about 1/100 the effectiveness of the eyestalks in concentrating *Penaeus* red pigment.

Perkins (1928) had found no influence of extracts of the central nervous system upon *Palaemonetes* red pigment. Hanström (1937a) found only very slight activity of an extract of central nervous organs of *Penaeus brasiliensis* upon the red pigment of that species. Knowles (1939) noted that extract of central nervous organs concentrated white pigment of *Leander adspersus*. In testing extracts of the nervous system of animals whose eyestalks had been removed three to four weeks previously, Knowles believed he had eliminated any criticism that the eyestalk might be the ultimate source of the chromatophorotropic material found in the nervous system.

Much of the early controversy over the central nervous source of hormone would undoubtedly have been eliminated had all the investigators considered that the total of the hormone producing tissue in the nervous system was probably of little or no greater volume than the sinus glands of the eyestalks. Investigators who commonly extracted dozens of eyestalks in 1 cc. of salt solution were apparently content to extract a single nervous system in one or even a few cc.

Abramowitz and Abramowitz (1938) extracted stomach, liver, muscle, and heart of *Uca* but found that these were without effect upon *Uca* black chromatophores even though the extracts were 100 times as concentrated as minimally effective eyestalk extracts. They did find that an extract of whole eyestalkless *Uca* (2 per cent solution) did show activity. It is remarkable that these investigators neglected to assay extracts of the central nervous organs alone, in the light of earlier published reports. In this connection Cunningham and Brown (unpublished work) have shown extracts of *Uca* central nervous organs to be very effective in dispersing *Uca* black pigment and that no other extra-eyestalk tissue will do likewise. These organs are, with little doubt, the source of the hormone giving rise to the diurnally rhythmic activity of the dark pigment of eyestalkless *Uca* (Abramowitz, 1938; Brown and Scudamore, 1940).

Conclusive demonstration that the central nervous organs contained a normal source of chromatophorotropic hormone was presented by Brown and Ederstrom (1940). These investigators observed that the shrimp, *Crago*, possessed in its telson and uropods extremely reactive melanophores. It was not unusual to see in normal animals the pigment of these organs completely dispersed while that of the remainder of the body was quite concentrated. When the eyestalks were amputated this "tail" melanin responded by a rapid and complete dispersion if it were not initially dispersed. Forty-five minutes to an hour after an eyestalk removal the black pigment gradually reached a state of complete concentration and in such eyestalkless animals would normally remain so for many days. Stimulation of the eyestubs in these animals would induce in five to eight minutes complete dispersal of this black pigment. After about an hour the pigment again concentrated and remained so until the stimulus was repeated. Nerve transection did not interfere with this reaction; therefore, it was unquestionably under hormonal control. Brown and Ederstrom injected extracts of various tissues of the body of *Crago* into eyestalkless specimens. The only extracts which were effective in dispersing the telson and uropod black pigment were made from the anterior end of the central nervous system. By far the most effective organs were the ganglia located upon the circumoesophageal commissures (commissural ganglia); next in effectiveness came the commissures just anterior and posterior to the ganglia; finally came the brain, the posterior half of which was more effective in inducing this response.

Further experiments indicated that the commissural ganglia were the actual sites of a hormone normally operating in black-background adaptation. Commissures of black-adapted animals yielded extracts of less potency than those of white-adapted ones. White-adapted individuals evidently accumulated the principle. That the exclusive points of origin of this "tail"-darkening hormone were the commissural ganglia themselves, and that the other effective regions obtained the hormone by diffusion from these ganglia was indicated by the fact that the ganglia proper were of equally high potency whether taken from black or from white-adapted animals, while the other anterior central nervous organs of black-adapted animals were almost entirely ineffective. Brown and Ederstrom searched in other crustaceans for this "tail"-darkening hormone. It was found in the other shrimp examined (*Palaemonetes*) but was apparently not to be found in the brachyurans examined (*Carcinus*, and *Uca*), and was only doubtfully present in the hermit crab, *Pagurus*. It will be recalled in this connection that the sinus glands of *Crago* and *Palaemonetes*, but not of *Carcinus* and *Uca*, possessed a principle antagonistic to this "tail"-darkening one (Section II, 1).

Very suggestive in relation to the preceding discoveries was the observation of Koller that the first parts of the body to darken (5–8 minutes) after injection of rostral-region extract were the telson and uropods. In certain other respects to be considered below, however, the effects of injection of extracts of the commissures were different from those obtained by Koller for the rostral-region extract.

The principal conclusions of Brown and Ederstrom were confirmed and considerably extended by Brown and Wulff (1941). The latter investigators found that injection of commissural extract into eyestalkless *Crago* produced effects upon all the chromatophore types of the body qualitatively similar to those obtained following upon strong stimulation of the eyestubs of similar animals. There was a strong dispersion of the black and red pigment of telson and uropods, a strong concentration of the black, brown, red, and yellow pigments of the rest of the body, and a strong concentration of white pigment everywhere. On the white pigment and the black and red pigment of the telson and uropods, therefore, the commissural ganglia extracts and sinus gland extracts acted in opposite manners, thus undoubtedly giving these pigments normally a dual control by two antagonistic hormones. On the other chromatophore types the sinus gland and commissural ganglia showed qualitatively similar activity, but that their activities in these other instances were not identical was seen in their reversed differential effects upon the black pigment of the monochromatic and of the tetrachromatic chromatophores.

Evidence was also put forth by Brown and Wulff to indicate that the extracts of the central nervous organs contained more than a single chromatophorotropic principle. First, although extracts of the commissural ganglia and certain neighboring nervous tissue were the only ones showing the "tail"-darkening activity, yet the remaining chromatophorotropic activities were found to a considerable extent in the ventral thoracic nerve cord as well. Thus spatially separated from one another in the nervous system were tissues whose extracts showed qualitatively different activities. Second, an absolute-ethyl-alcohol-soluble fraction of the commissural ganglia showed very strongly all the activities characteristic of the commissures except the "tail"-darkening action. The alcohol-insoluble residue contained the latter. Continued alcohol extraction of the commissures either gradually destroyed the "tail"-darkening principle or converted it into an alcohol-soluble material having the same effect on chromatophores as the initially obtained alcohol-soluble fraction. Evidence that the melanophore contracting principle from the central nervous organs may normally be in good part responsible for body lightening is found in the fact that undisturbed animals commonly are found with pale body and black telson and uropods. This apparently could not happen *unless* the body lightening were occasioned by the melanin concentrating principle of the central nervous system or, by a substance similar to the alcohol-soluble fraction alone, from the sinus gland. Interestingly, the latter would not contain the *Uca* black pigment dispersing principle in any abundance.

There arises the question as to whether either of the two principles from the central nervous organs of *Crago* can possible be the one with which Koller (1928) was dealing in his extracts of the rostral region. From his description it would seem unlikely that he included the commissural ganglia in his extracts. It is possible that a melanophore dispersing principle might pass from the commissural ganglia to a blood-sinus in the dorsal-anterior region of the animal and that this was the material with which Koller dealt. Highly suggestive in this connection were the observations of Brown and Wulff (1941) that when the eyestubs of eyestalkless animals were stimulated strongly the responses of the chromatophores were such as would result when all water extractable hormones were liberated from the central nervous organs (darkening of the telson and uropods and blanching of the remainder of the body), whereas weak electrical stimulation of the eyestubs resulted in a response quite different from that produced by any extract but quite like that obtained by Koller's injection of rostral-region extract. It would appear that weak eyestub stimulation induced the liberation of selected materials from the nervous system, perhaps the "tail"-darkening principle which may also be a body-darkening one when present without the other central nervous principle (having an opposite and dominant action upon the body pigments but not upon the "tail" black). Such an explanation appears much more reasonable that one postulating that nervous stimulation results in the elaboration of a specifically different molecule, since the stimulus is very brief and the discharge apparently follows immediately. However, the possibility is not ruled out that in this case, as well as with other active extracts, the usual water or alcohol extraction does not give us the normally functional hormones, but rather related active substances or groups.

More recently, McVay (1942) has made an extensive study of the chromatophoric activities of extracts of central nervous organs of the crayfish, *Cambarus*. As indicators of activity she used, exclusively, red and white chromatophores on isolated portions of the carapace of *Cambarus* according to the technic employed by Brown and Meglitsch (1940). She found that extracts of the central nervous system were highly effective in concentrating both red and white pigments. A study of the distributions of the activities upon these two pigmentary types showed that these distributions were not identical. For example, all the thoracic ganglia were roughly of equal effectiveness upon red pigment whereas upon white, there was a dropping off of activity in passing posteriorly along the cord. While the brain always showed strong effect upon red pigment, its effect upon white varied from high effectiveness in the case of some animals to almost none in others. In brain extracts showing little or no activity, the extracts were usually rendered much more active by boiling. Such an increase in activity was slight or absent in extracts initially showing high activity.

Confirmation that she was dealing with two active principles in the nervous system came in the demonstration that 100 per cent ethyl alcohol extraction removed a fraction only effective upon red pigment. The alcohol-insoluble fraction showed a strong action upon both red and white. Partial separation was also readily obtained by differential adsorption. The white-influencing principle was apparently more readily adsorbable than the red.

Thus far, a true endocrine activity of the crustacean central nervous organs has not been shown for any function other than chromatophore control. But as with the sinus gland of the eyestalk it seems highly probable that we are dealing here with an endocrine source having a more fundamental activity within the animal than color adjustment. Adult *Cambarus* nervous systems show very strong activity yet such individuals show little or no color adaptability.

We know nothing as yet regarding the cellular elements in the nervous system responsible for the formation of these materials. Thus, we can not say whether the responsible cells are simultaneously functional nervous elements or whether they are cells merely spatially associated with the active nervous elements. Histological search of the nervous system for secretory elements is much needed here.

As for the chemical nature of the substances involved, all we can say is that they are not significantly soluble in such fat-solvents as ether, and chloroform, that they are all soluble in water, and that certain ones are very soluble in ethyl alcohol. All are resistant to the temperature of boiling water. Since they are associated with nervous tissue we immediately suspect that the materials are similar to, or identical with, adrenalin or acetylcholine. But their physiological actions are quite different. Adrenalin disperses crustacean white pigment (McVay, 1942); nervous system extract concentrates it. Acetylcholine has no effect upon crayfish red chromatophores.

Beyond chromatophoric activities one can suggest that possibly a hormone liberated from the central nervous organs is responsible for the rhythmic variation in calcium deposition in the gastrolith as described by Scudamore (1942). Also suggestive of possible normal functions are the observations of Scudamore that both injection of brain extract and stimulation of eyestubs of stalkless animals result in an increased O_2 consumption, and the observations of McVay (1942) indicating a seasonal change in the concentration of the white-chromatophore-contracting principle from the brain of female crayfishes and a striking difference between males and females in the total amount present.

The work already done upon hormone production by the crustacean central nervous organs has merely exposed the field. Just enough has been done to lead one to believe that the rôle of such hormones is not a secondary one in color-change physiology. It would appear that further work upon the humoral rôle of the nervous system of crustaceans will yield highly profitable results and contribute significantly to our knowledge of crustacean endocrinology.

VI. THE GONADS

The problem of whether the crustacean gonads produce hormonal materials responsible for the differentiation and maintenance of secondary and accessory sexual characteristics is far from solved at the present time. What little indication we have of such an activity does not come from surgical extirpation, implantation, or injection of extracts of gonads, nor even from the histological demonstration of secretory elements within these organs which might be interpreted as endocrine. Instead, what suggestion we have of sex hormones being produced by the gonads comes from (a) observations upon the effects of parasites upon the gonads and sex differentiations ("Parasitic castration," Giard, 1886); (b) observations upon parallel cyclic changes in the gonads and certain secondary sexual characters; and (c) results of radiation of the organism by X-rays or radium rays involving parallel suppression of gonadal activity and differentiation of certain sex characteristics. Let us examine very briefly each of these three classes of data.

A relatively large body of information has accumulated upon the effects of "parasitic castration" in crustaceans. The principal investigations in this connection are listed in Table 3. The parasites involved are principally rhizocephalans such as *Sacculina* and *Peltogaster* whose free swimming cypris larval stage attaches itself to the crustacean host and there metamorphoses into the definitive parasite consisting principally of a sac-like portion containing only the reproductive organs and root-like hausteria penetrating the whole host, phagocytizing the host tissues. Connective tissues and gonads appear to be the principal organs attacked.

Other parasites include epicarid isopods, the Bopyridae, which commonly live in the branchial chamber of their host which they enter as a larval form resembling a small free-living isopod. As an external parasite it loses certain of its isopod characteristics and sucks juices from its host by means of its modified piercing and suctorial mouthparts.

Still other parasites include helminth worms in their adult or larval stages, these often living in the body cavities.

It has been observed quite generally that an effect of a parasitic infestation is to suppress the growth and development of the gonads and often even to cause their degeneration. The degree of this suppression or degeneration, however, varies widely with both the parasite and host, and varies all the way from a somewhat reduced gametogenic activity to almost complete absence of the gonad. Very characteristic of the ovary of the parasitized animal is failure to deposit yolk.

A. Male hormone

Among the decapods the usual effect of parasitic castration of the males is a change of the infected males in the female direction. This change involves modification of the abdominal pleopods; changes in the width of the abdomen; changes in the size and form of the chelipeds, etc. Callan (1940) was unable, however, to find any modification of the secondary sex characters of male *Leander xiphias* and *L. squilla* parasitized by *Bopyrus*, even though these individuals showed extreme reduction of the gonads. On the basis of his results and also the earlier work (see also Tucker, 1930) upon the induced and normal occurrence of hermaphrodite gonads Callan concludes that crustaceans show a graded series with respect to their tendency

TABLE 3

Studies upon parasitic castration

HOST	PARASITE	INVESTIGATOR	
Stenorhynchus phalangium	*Sacculina*	Giard	1886
Brachyura	*Peltogaster*		1887 a, b, c
Eupagurus	Entoniseid isopods	Giard	1888
Palaemon	Epicarid isopods		
Galathea intermedia	*Pleurocrypta galathae*	Bonnier	1900
Eupagurus meticulosus	*Peltogaster curvatus*	Potts	1906
Inachus			
Inachus mauretanicus		Smith	1906
Eriphia spinifrons			1910
Pachygrapsus marmoratus	*Sacculina*		1911
Carcinus maenas			1913
Eupagurus excavatus	*Peltogaster sulcatus*	Smith	1910
Carcinus maenas	*Sacculina*	Potts	1910
Inachus		Robson	1911
Eupagurus excavatus			
Eupagurus bernhardus	*Peltogaster*		
Eupagurus cuanensis		Guerin-Ganivet	1911
Galatheae despersa	*Lernaeodiscus galathea*		
Munida bamffic	*Triangulus munidae*		
Carcinus maenas	*Sacculina carcini*	Courrier	1921
Anapaguris chiroacanthus	*Peltogaster sulcatus*	Nilsson-Cantell	1926
Eupagurus cuanensis	*Peltogaster paguri*		
Macropodia rostrata	*Sacculina neglecta*	Perez	1929, 1934
Upogebia stellata	*Gyge branchialis*	Tucker	1930
Gammarus pulex	*Polymorphus minutus* (Acanthocephala)	LeRoux	1931a
Eriocheir japonicus	*Sacculina gregaria*	Okada and Miyashita	1935
Carcinus maenas	*Sacculina*	Day	1935
	Triangulus munidae		
Munida sarsi	*Lernaeodiscus ingolfi*	Brinkmann	1936
	Triangulus boschmai		
Leander xiphias	*Bopyrus xiphias*	Callan	1940
Leander squilla	*Bopyrus helleri*	Knowles and Callan	1940
Upogebia littoralis	*Gyge branchialis*	Hughes	1940

towards intersexuality in the sex-determining mechanism. The parasite would then act only in tipping the balance from male to female. *Leander* would appear to stand at one end of the series and such forms as *Upogebia* (Tucker, 1930) would stand at the other. In support of this explanation by Callan are also the observations of Rünnstrom (1925) demonstrating normal hermaphroditism in *Calocaris* and *Gebia*, and of Turner (1935) giving indications that *Parastacus* evolved from hermaphroditic ancestry.

These changes of the parasitized male toward the female form have been variously explained by different investigators. One of the more generally accepted explanations is that put forth by Smith (1909–1912) and supported by Robson (1911), Tucker (1930), and Hughes (1940), and to some extent Callan (1940). This was based upon the fact that female crustaceans possessed far more fatty materials in such tissues as liver and blood than males. It was believed by Smith that a "sexual formative" substance acted upon the development of both the gonads and the secondary sexual characters. This "sexual formative" stuff can well be interpreted as hormonal in nature. Smith believed it was a substance associated with the modified fat metabolism of the female organism. Since parasitized males also showed the increased fat content, it was believed by Smith and others that the parasite imposed the same metabolic demand upon the organism as normally would the developing eggs within the ovary. Consequently, the parasitized males would possess in good quantity the "sexual formative" substance normally found within the female, and its secondary sexual characteristics would be correspondingly modified. This interpretation does not call for a hormone secreted by the testes. Rather, it calls for the presence of a humoral substance at a more primitive level, namely one responsible for sex-determination itself.

Goldschmidt (1931) considers that the results of parasitization in crustaceans may be a direct case of intersexuality. The effect of the parasite according to this view is one of interference with the normal expression of the sex genes.

Biedl (1913) suggested that the parasite, which he believed to be female, liberated a feminizing hormone into the blood of its host.

Lipschütz (1924) and later Van Oordt (1928, 1929) presented still another interpretation for the feminization of male crabs following upon parasitic castration. They considered that the parasitized males reverted to neutral form; the results of castration, therefore, deprived the animals of the male hormone normally secreted by the testes. In support of the production of a male hormone by the testes were also the results of Brinkmann (1936). He found that when male *Munida sarsi* were parasitized by *Triangulus munidae*, which brings about a total atrophy of the gonads, and by *Lernaeodiscus ingolfi*, which induces a partial atrophy, there is a modification of the abdominal pleopods to the female condition. Parasitization by *Triangulus boschmai*, the largest of these parasites and therefore one probably making the largest nutritional demands upon the host, leaves the gonads still functional but in a reduced degree, and does not bring about any modification of the external secondary sexual characters. Brinkmann believes, nevertheless, that hyponutrition caused by the parasite cooperates with a male hormone deficiency in giving rise to his observed results.

Courrier (1921) also believed the results of parasitic castration to be due to the removal of the source of a sex hormone. In his experiments with *Carcinus*, however, he observed that there was no correlation between the degree of feminization and the amount of testes atrophy. In fact, in some instances where feminization was maximum spermatogenesis was still proceeding in the testes. A similar lack of correlation was observed for *Eriocheir* by Okada and Miyashita (1935). Courrier concluded that the hormone source could not lie in the testes themselves, but rather must lie in some other tissue. Parasitization was thought to result in the destruction of this tissue.

The simple absence of a male sex hormone as explaining the results of parasitic castration of male decapods has been questioned by Goldschmidt (1931) who pointed out that the neutral decapod form is probably not the female one.

Also against this hypothesis is the observation of Turner (1935) that copulatory appendages appeared unilaterally in a specimen of *Cambarus;* the observations of Nillson-Cantell (1926) that the relative feminization of the copulatory pleopods and the other pleopods was reversed when *Anapagurus chiroacanthus* was parasitized by *Peltogaster sulcatus* on the one hand and *Peltogaster paguri* on the other; and the observations of Callan (1940) that in parasitized *Leander xiphias* and *L. squilla* there was no feminization though the testes were often greatly suppressed in their activity.

Difficult to interpret in any other manner than by a seasonal variation in concentration of a male hormone are the results of Scudamore (1942) upon the copulatory appendages of *Cambarus*. These appendages are known to assume the sexually functional form (form I) at the time of the late summer molt, and resume the sexually non-functional form (form II) at the spring molt. The work of Fasten (1914) indicated that during the summer the testes are large and active, decreasing in September and remaining small and inactive until the following summer. Thus the time of normal change of the copulatory appendages from the non-functional to the functional form coincides with the increased testis activity and the normal reversion occurred at a time of low activity of the gonad. Scudamore found that molting artificially induced in late fall and winter months by sinus gland removal invariable resulted in form II regardless of the initial form. It was not possible to conclude whether any hormone involved here was actually liberated from the gonad or whether both gonads and appendages were simultaneously influenced by a hormone originating elsewhere. This seasonal transformation of the copulatory appendages of the crayfish, and the regeneration of characteristic male-form appendages (*Uca* and *Alpheus*—Darby, 1935) appear very promising as means of attacking the whole problem of male hormones in crustaceans.

B. *Female hormone*

In general, in parasitic castration of female decapod crustaceans there is little or no change in the secondary sexual characteristics. What little change does occasionally occur appears to be slightly less complete differentiation.

Recently, Callan (1940) has studied the influence of parasitic castration of *Leander* by certain bopyrids and has found that when females are parasitized, these females fail to develop during the breeding season the structures normally associated with their abdominal incubatory chamber. These structural changes in normal animals are temporarily associated with increased ovarian activity which is absent from the parasitized individuals. That this effect was not a result of failure to molt was seen in the fact that parasitized animals molted more frequently than normal. Callan found that castration of females by X-ray also resulted in failure of the incubatory chamber to develop. Knowles and Callan (1940) described special white chromatophores which normally developed on the egg-bearing segments of female *Leander*. These also failed to develop in parasitized or X-ray-castrated individuals. These results were considered by Callan to give some, though not conclusive, evidence for the existence of a female sex hormone.

An apparent relationship between the normal production of the brood-pouch in *Asellus* and normal ovarian activity was suggested in the work of Haemmerli and Boveri (1926). These investigators found that injury of the ovaries by the action of radium resulted in the failure of the brood-pouch to develop. Mori (1933) obtained similar results upon irradiating female *Daphnia*.

LeRoux (1931a, b) found that when female *Gammarus pulex* were parasitized by the acanthocephalan, *Polymorphus minutus*, there was suppression of gonadal activity and failure of the marginal bristles of the oöstegites to develop. By radiation she was able to inhibit for a period the development of the ovaries. Under these conditions the marginal bristles failed to appear though the animal continued to molt. Bristles formed only after radiation had ceased and the vitellogenesis of the oöcytes occurred. It would appear from these results that the bristle development was in some manner dependent upon oögenesis.

All the results obtained by radiation must be regarded with some caution inasmuch as the exact extent of the damage done is not readily ascertainable, especially in those instances in which the whole organism is irradiated as is usually the case with small animals.

Additional support for the hypothesis of an endocrine activity of the ovaries are the observations of Miyashita (1933) that a parasitized female *Eriocheir* showed a persistent juvenile abdomen, and that of Day (1935) pointing to a correlation in the rate of *Carcinus* abdomen growth and the time of sexual maturation.

General

We must conclude, after viewing all the foregoing data, that there are in all probability sex hormones active in crustaceans. The evidence pointing to the testes as a source of a male hormone is still most inconclusive. Evidence indicating the ovaries to be the source of female hormone is slightly better. But as was pointed out by Brown (1941) and Kleinholz (1942) definite demonstration of such a function must be dependent upon the results of surgical removal of the glands involved, and either gland implantation or gland extract injection. None of these has yet been done for any crustacean.

VII. GENERAL SUMMARY AND CONCLUSIONS

1. It is well established from the effects of eyestalk removal and injection of eyestalk extract that the eyestalks contain sources of hormones influencing all chromatophore types found in crustaceans. The specific source within the eyestalk of the hormonal material affecting all the chromatophore types thus far examined is the sinus gland.

2. Comparison of the effects of water extracts and of alcohol-soluble and alcohol-insoluble fractions of sinus glands have demonstrated a minimum of three chromatophorotropic principles in this gland. Every species examined contains at least two.

3. Removal of eyestalks, extirpation of sinus glands by themselves, and implantation of sinus glands have conclusively shown the sinus gland to be the source of a molt- and consequently a growth-inhibiting hormone. There is evidence that the molt-inhibiting hormone also controls simultaneously the respiratory, water, and calcium changes normally associated with molt.

4. From injection of sinus-gland extract, and the fact of a normal variation in activity of extracts of the gland paralleling normally induced changes in retinal pigments, comes evidence that a sinus gland principle is responsible for the normal movement of certain of the retinal pigments to the condition for light adaptation. Physiological evidences point conclusively to the fact that this retinal-pigment-influencing principle cannot be the one which affects the dark chromatophores.

5. Eyestalk removal and eyestalk-extract injection suggest strongly that hormonal material arising in the eyestalk influences metabolic rate, heart rate, and general motor activity. Studies upon the correlation between heart rate and chromatophore state appear to indicate that, at least in *Palaemonetes*, a single hormone from the sinus gland both concentrates red pigment and accelerates heart beat.

6. Eyestalk removal, sinus gland extirpation, and implantation of sinus glands indicate conclusively that this gland possesses a favorable action upon viability. There is as yet no satisfactory explanation as to what specific action upon the organism is responsible for this effect.

7. From injection of extract of the ganglia together with the demonstration of a variation in the quantity of active principle in them following normally induced changes in certain *Crago* chromatophores, it is established that the ganglia upon the circumoesophageal commissures of such macrurans as *Crago* and *Palaemonetes* produce a chromatophorotropic hormone with physiological effects antagonistic to a sinus gland principle upon certain *Crago* melanophores and erythrophores. This principle is insoluble in absolute ethyl alcohol. It is absent in the brachyurans that have been examined.

8. All of the principal central nervous organs of crustaceans, upon extraction, yield a substance chromatophorotropically active. In the species which have been examined this substance is soluble in absolute ethyl alcohol. Upon some chromatophore types its action is qualitatively similar to sinus-gland extract; upon other types its action is antagonistic.

9. The results of parasitic castration of male crustaceans and the fact of a correlation between seasonal testis activity and the differentiation of certain secondary sexual characters find a reasonable explanation in the hypothesis that a male sex-hormone is being produced in the male gonad or in some other organ of the body.

10. The results of parasitic castration of female crustaceans and of experiments involving destruction of the ovaries by radiation suggest strongly that a female sex-hormone is normally liberated from the ovary. This hormone appears to control differentiation of brood-pouches and other structures concerned with the care of the developing young.

11. The fact of a *Schwarzorgan* in the rostral region of certain crustaceans as described by Koller still remains to be confirmed.

12. The X-organs of crustaceans appear from their histological picture to be endocrine glands, but as yet no function has been attributed to them.

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STUPOR MUNDI ET IMMUTATOR MIRABILIS

A review of *The Art of Falconry:* being the *De Arte Venandi cum Avibus* of Frederick II of Hohenstaufen. Translated and edited by Casey A. Wood and F. Marjorie Fyfe. *Stanford* (Stanford University Press) and *London* (Oxford University Press), 1943. Pp. cx + 673. 11 x 8½ inches. $10.00.

By Robert K. Burns, Department of Embryology, Carnegie Institution of Washington.

The Emperor Frederick II of Hohenstaufen, King of Jerusalem, ruled over the Holy Roman Empire from 1220 to 1250 A. D. Emperor and German King by election, he was, through his mother, hereditary King of Sicily and Naples, the descendant of a celebrated line of Norman Kings. He led a remarkable life in a remarkable age, dying before he was fifty-six, justly regarded by his contemporaries as the greatest figure since Charlemagne. Although the Emperor and his reign have not been slighted by history, it may be claimed that the greenest of his laurels stems from the fact that out of a crowded and turbulent life he seized time to write a lengthy treatise entitled *De Arte venandi cum Avibus*, upon the subject that was always closest to his heart, fondly called ever since by followers of the art *The Emperor's Falcon Book*.

Several fine manuscripts of this work are known in mediaeval Latin, none entirely complete, of which those in the Vatican Library and at Bologna are apparently closest to the original. Later, printed texts appeared, but this large and beautiful volume is the first translation in English, and the only complete one in any language. That the task of translation and collation should have fallen to Casey Wood and his sympathetic collaborators, is the best fortune to befall since the Emperor first set himself to his pleasant task. For each the work was so obviously a labor of love that a kindred feeling soon pervades the modern reader. The translators have taken great pains not only to convey the substance and flavor of the original in a simple modern style, but have done much besides to recreate the spirit and reality of Frederick's time. The book is lavishly illustrated with facsimile pages from the best MSS, and many of the beautiful original illustrations are handsomely reproduced. There is an historical introduction by Casey Wood and a special section dealing with source MSS and early printed texts. Other appended articles provide a brief account of the Hohenstaufen family; a description of present-day remains of the castles and hunting lodges of the Emperor, with pictures of the south Italian terrain over which he went afield; commentaries on the subject by modern falconers; a carefully compiled roster identifying the birds mentioned and apparently familiar to the Emperor; and a wealth of other illustrative material of many kinds, contemporary and modern. There is an annotated bibliography of falconry, an extensive and very essential glossary of terms, and an index. The workmanship and appearance of the book do credit to all concerned.

The art of training hawks for hunting is a very ancient one, known in all ancient lands and still practiced in many—as old apparently as civilization itself. Were its evolution known fully we would no doubt have the most fascinating chapter in the history of animal domestication. Among man's "animal friends" most were destined to be eaten, or otherwise exploited in a less than amicable manner; a few, however, came to enjoy a less hazardous relationship with their human overlords. Their value lay in some special service, in the performance of which companionship of a sort was possible—to be useful they had to be able to enter into human schemes and purposes. The dog has been said by some to have adopted man, rather than the reverse; and while the earliest use of the horse is largely conjectural, in each case a certain spiritual bond unquestionably develops. But it is doubtful whether sentiment in any form ever mollified the fierce heart of a hawk; and it was indeed a feat of intelligence and self-discipline when savage man found the way to bind the more savage bird to his service, without impairing the fierce spirit that made him useful. Undismayed by the lack of such concepts as *tropism* and *conditioned reflex*, but nevertheless well acquainted with the nature of instinct, the primeval falconer proved himself a master of technique, and in time evolved a system of training that the modern disciple of the art has found it difficult to improve on. The achievement required knowledge, keenness of observation, and an analysis of bird personality that would do credit to the scientific student of animal behavior. This ancient art, descended through centuries of apprenticeship, came to be the Emperor's absorbing hobby.

But as the master of the falconer's art is above the mere huntsman, out for the sport and the kill, the Emperor Frederick was more than a royal patron of a fascinating sport. He had a wide knowledge of almost every aspect of natural history; and was as much concerned with the classification, structure and habits of the diverse types of quarry, as with the superior attributes of his noble charges. He combined the practical talents and experience of the expert falconer with powers of observation and insight that made him the most gifted naturalist of his time. His mind was remarkably unprejudiced and inquisitive, and he relied mainly on his own observations, frequently rejecting the traditional beliefs so prevalent in the natural history of his day. For example, he sent emmissaries to the far North to inquire into the origin of the "barnacle goose" legend, and bring back evidence. Unimpressed with the results he dismissed the tale as fiction. He did not hesitate to question the accuracy of Aristotle (whose works he knew well) when he found things in conflict with his own observations, condemning him for relying on second-hand accounts. He experimented with the behavior and senses of birds; proved that vultures locate their prey by sight and not by smell; used artificial incubation on the eggs of falcons (the resulting young lacked self-reliance and were prone to become "screechers"); and is said to have directed that children be reared in isolation to discover the origin of the faculty of speech. He personally tested the methods of Oriental and European falconers in order to satisfy himself as to the best procedures; and is credited with many innovations, such as the use of the hood in place of the usual practice of "seeling," or closing the eyelids with sutures. Consequently, the Emperor's book is much more than a manual for the "compleat" falconer.

The work begins with an apology for falconry and a general classification of birds, which are divided into *land birds*, *water birds*, and *"neutral" birds*, by which we might nowadays understand *shore birds*. He also separated the former into raptorial and non-raptorial divisions. Book I deals chiefly with the structure and habits of birds. He describes vividly the manner of flight and flying formations of various groups; seasonal migrations, diurnal flights to and from feeding grounds, manner of seeking and capturing food, winter quarters, mating and nesting, and care of the young. He states remarkably clear conceptions of structural adaptation in relation to modes of progression, feeding habits and general way of life. The Emperor then proceeds to a description of structure. He examined internal structure with more than mere curiosity, showing some appreciation of tissues as constituents of organs and grosser parts, and distinguishing between organic and "homogeneous" parts. He discourses upon the structure of beaks as adapted for the seizing and handling of foods; and in a remarkably accurate description of wings, phrases his account in terms of the mechanical requirements of flight. The number of joints, the arrangement of the bones, the action of muscles are described, with rapidity and flexibility of motion as the end to be served. The form and arrangement of the feathers are related to the same purpose. He remarks upon the spongy or hollow structure of bones, as permitting both lightness and strength; it is difficult however to read into his words, as translated, the interpretation of Sarton, that he discovered the pneumaticity of the bones. However, at times bethinking himself of his audience, he does not hesitate to be explicit about the obvious—"feet and claws [also] enable the animal to scratch where it itches, and to dig in the earth as the bird pleases." After describing the tongue, the essentials of vocalization are boiled down as follows: "but all have at least three calls, one when they are hungry, another when they wish to copulate . . . and a third incited by fear"—basic avian, no doubt. Only parrots pronounce the letter "R" adequately.

Much space is devoted to plumage but because of the innumerable combinations he is not to be diverted into a long dissertation on colors. However, he refers to protective coloration and is familiar with the minutiae of juvenal and adult plumages. Feathers are classified as down, plume and flight feathers, and he did not overlook the diminutive after-feather. The number, arrangement and detailed form of flight feathers interested him deeply—details that are of obvious importance to the practical falconer. Peculiarities in the flight of other birds occasionally require special explanation, and sometimes must be explained at any cost: thus, the eccentricity of the tumbler pigeon is "perhaps because of good spirits and cheerfulness." The phenomenon of moulting is treated at length, because of its practical importance to the trainer and conditioner of hawks. The regular order in which flight feathers are lost, the rate of growth and replacement, careful attention to feeding in order to insure strong pinions, are all stressed.

Book II takes up the types of hawk useful in hunting, care and handling, equipment, and the early stages of training. This book is likely to be the most interesting of all to the general reader. The remaining books have more of the character of a field manual, but the wealth of experience on which the Emperor draws, and the charming simplicity with which it is dispensed, relieve every possibility of dullness. Few are the situations not encountered personally, and for which a tested remedy is not at hand; none is too trivial to receive the most careful attention, lest the future training and value of the hawk suffer. His instructions are explicit, encompassing not only the type of quarry but terrain, weather and species of hawk. As an example of how far the Emperor deems it his duty to go, we may cite chapter headings as follows: Of Falconers and their Qualifications [not greatly inferior to those of a good emperor]; Of the training of the seeled Falcon through the Senses of Taste, Hearing and Touch; How to carry a Falcon out of and into a Mews through a Doorway; On various Classes of Falconers who, reprehensibly, do not use a Lure. Having an English wife (daughter of the ignoble John) Frederick takes more heed of Britain than was then customary with Roman Emperors, and tells us: How Falcons are lured in Britain. "We inquired why they do not call out [in luring] but they could only reply that it is their customary practice." Here Casey Wood could not help interjecting: "A sufficient British reason." There is advice: On Falcons flown in a Cast (pair) who crab while standing on the Quarry; Of Shirkers and the Treatment of their Infirmities; On Heron Hawking with Sakers, swift in Flight but fearful of watery Areas; On Falcons that rake away (fly off) before Ducks are put up. Such are a few of the situations that make the falconer's day, and may make or unmake the falconer—most probably the latter.

But despite the contagious enthusiasm of Frederick for his subject, many a reader of his book will be even more strongly attracted to the Emperor himself. Grandson of the legendary Barbarossa, modern historians say that much of the glamor and romance ultimately gathered about the grandfather derives from the memory of the more versatile second Frederick—a process familiar enough in the making of heroes and epics. With all the duties and distractions of a Roman Emperor, and with more than the usual quota of wars (in which, though competent enough, he took little pleasure—the only decisive battle he lost came, it is said, when he went off hawking, leaving the fight to his generals) he yet found time for an incredible number of intellectual activities. He was the author of an enlightened code of law. Through his Sicilian Kingdom, and his contacts as crusader, Frederick became an admirer of Saracen learning. He displeased and angered Popes by his enthusiasm for Arabic culture, and a too-obvious conviction that holy wars were barbarous, futile and destructive of civilization. Probably no emperor knew more the papal ban, or regarded it less. He was founder of the University of Naples (1224), by repute the first to be established by royal charter (Sarton: *Introduction to the History of Science*, Vol. 2, Part 2, 1931). His brilliant court at Capua and Palermo harbored the greatest scholars of the day—European, Jewish and Arabic. Here the celebrated Michael Scot, who in later times acquired a more dubious renown as astrologer and "dread wizard" (see Scott's *Lay of the Last Minstrel*) translated, at the Emperor's behest, many of the works of Aristotle, Avicenna and others, especially those dealing with natural history, with all of which Frederick became conversant. Here the first recorded sonnet was written by a favorite of the Emperor; and here also came Leonard of Pisa, who introduced Arabic numbers to Europe. Frederick was himself an accomplished mathematician and linguist, translated or personally supervised the translation of a Saracen book of falconry, and is known to have written a zoological work *Liber Animalium*, which unfortunately has not survived. It may have been in connection with this effort that he maintained a large zoo (which travelled with the court), containing many exotic animals imported at great cost. He proudly exhibited in Italy and Germany the first giraffe seen in Europe, obtained it is said from the nephew of the redoubtable Saladin, in exchange for a polar bear—a fair trade it would seem, if there was no more to this deal than meets the eye. It is recorded that the bear caused a sensation in Damascus. All this he was able to do largely through the widespread contacts he maintained for the collection of African and Asiatic hawks. The extravagance entailed he justified on the grounds that animal collections and the study of animal life are both useful and instructive.

So many and so great, in fact, were Frederick's contributions to learning and culture that it has sometimes been difficult to know where to stop. Nordenskiöld (*History of Biology*, 1935) says, for example, that Frederick founded the Medical School at Salerno; where, by the Emperor's dispensation, it was possible to dissect the human body for the first time since the Alexandrine era. Wood ignores the first part of this statement but apparently accepts the second (Introduction, p. xxxvii). Neither is in accord with recent authorities; although it is true that Frederick was a generous patron of the Salerno school, and established strict standards for the study of medicine, and the registry of qualified physicians (Sarton: *Introduction to the History of Science*, 1931 and Sudhoff: *Geschichte der Medizin*, 1922). However, the teaching of medicine at Salerno goes back to the 10th century, antedating the existence of the university itself (Singer: *The Evolution of Anatomy*, 1926). Instruction in anatomy at Salerno in Frederick's day was based, so far as we know, on the dissection of animals; and there is no good evidence that human dissections were carried out in Europe before 1300, and then at Bologna (Singer, Sarton). That Frederick might have gone so far, is wholly in keeping with his character; that he probably did not, detracts but little from his fame as "Stupor mundi et Immutator mirabilis." Innovator extraordinary he was indeed, and herald of the Renaissance.

BRIEF NOTICES

GENETICS

Genes and the Man.
By Bentley Glass. Bureau of Publications, Teachers College, Columbia University, New York. $3.50. 8½ x 5⅝; xii + 386; 1943.

This book presents a simple outline of human biology in a remarkably well-integrated form. It begins with a brief account of the cell and cell multiplication, and introduces the elementary principles of genetics to show clearly the advantages derived when sexual reproduction is superimposed on the primitive type of reproduction by fission. Sex determination is considered, and there follows a discussion of the development of the human organism from its conception to maturity, relating the interdependent effects of organizers, genes, and hormones. The last chapter gives special consideration to the relations of the organism to its environment, to disease and resistance, and to the problem of ageing.

While the main emphasis is on human biology, the author does not ignore more general aspects. For instance, lower plants and animals are included in the discussion on the cell and cellular organization, different types of sex determination are reviewed, and in the section on development comparative embryology is stressed. In this way the field of comparative anatomy is opened up, although it is not considered in any detail. In a similar way, although no detailed physiology is included, continual reference to the function of various organs direct the reader's mind into this field.

The defects of the book are of a minor nature. For example, it seems rash to attribute to heterochromatin a function in spindle-formation and chromosome disjunction, on the basis of its localization near the centromere in *Drosophila* (p. 28). The reviewer is unaware of any tendency towards doubleness in flowers of tetraploids (p. 27, footnote). Again, although the author states the belief that chiasmata are the result of crossing-over, the diagrams (mostly showing only 2 strands) do not make it clear how this would come about, but suggest, on the contrary, that the chiasmata precede, and are eliminated by, crossing over. (With this exception, the diagrams are clear and helpful.)

This is a book which any interested layman might read, but as stated in the preface it is designed primarily for educators. A college course in introductory biology developed from the viewpoint and outline presented here, with additional material, should maintain a high level of interest and give the student a real appreciation of biological principles and their meaning in his own life.

GENERAL BIOLOGY

Essays in Biology, *in Honor of Herbert M. Evans. By His Friends. University of California Press, Berkeley.* $10.00. 10¼ x 6⅝; xxvii + 684; 1943.

No less than 58 friends of the distinguished Director of the Institute of Experimental Biology of the University of California joined in the writing of this handsome volume in honor of his sixtieth birthday. The committee on arrangements invited contributions representative of the whole range of Dr. Evans's interests during his scientific career. In spite of all the unsettlement of wartime, 48 papers have been assembled, on topics in anatomy, embryology, the physiology of reproduction, endocrinology, nutrition, history of medicine and of general science, and several other subjects. The contributors as well as the topics represent the varied contacts of Dr. Evans's life, for they include one or two of the older men whom he would number among the leaders of his youthful thought, some of his earliest Baltimore colleagues, his first students in Baltimore and in Berkeley, former and present members of his Berkeley departments, colleagues from other departments and other universities, and even several scientists of different nations, bound to him by strong ties of professional interest but whom he could only have met in the course of travel. In compensation for the absence of Europeans who might have been included but for the distractions or the blockades of war, first-rank investigators of three South American countries are happily included.

No one of these friends would have wished to intrude into such a volume any heavily monographic disquisition upon the more recondite of his inquiries; on the contrary each contributed either a brief excerpt from recent research, a review of some phase of his life work or current field of study, an essay in history or folklore, or a translation from one of the classics of science.

The resultant collection of short pieces, many of them introduced by a particular word of dedication to Dr. Evans, reads very much as if these threescore men of science had met together for a few days to talk over, each in his own way, whatever matters of scholarly interest happened to be uppermost in their minds—thus paying their old friend Herbert Evans the very great honor of confidence that he would understand and appreciate all their diverse reflections. It must have warmed his heart to know that in this hard and bitter time in which he must pass his sixtieth birthday such a gathering of science and humane learning could take place, if not in personal actuality, at least within the covers of a book dedicated to him.

Regardless of the brevity of these papers and of the sociable impulse which brought them together, there is much of scientific importance in the volume. The presence of 14 articles by experienced investigators on the physiology of reproduction and 10 contributions to the history of medicine and science, to say nothing of the papers on other subjects, would be sufficient to make the book a necessity in private and institutional libraries.

No one reviewer could fairly discuss all these contributions, even if there were space to do so. Among those which are sure to be read with special interest we may, however, safely cite R. R. Bensley's study of the localization of lipids in cytoplasm; B. A. Houssay's account of hypophysial diabetes, in which the contributions of three continents are arranged in historical perspective; G. W. Bartelmez's translation of Purkinje on the bird's egg; C. H. Danforth's analysis of the relationship between hormones and the action of the so-called gene H on cock feathers; Alexander Lipschütz's classification of the tumorigenic action of estrogens; and the announcement of experimental production of pseudohermaphroditism in monkeys by G. Van Wagenen and J. B. Hamilton.

The volume contains the *curriculum vitae* of Professor Evans and his complete bibliography arranged by years. The editorial hand has been light and skillful. The typography is attractive, and the illustrations, especially the line engravings, have been well reproduced, considering wartime conditions. The frontispiece is a photogravure portrait of Evans, which reflects the strength and determination, but scarcely the flashing charm and quick sensibility of his many-sided personality.

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BIOLOGICAL RESULTS OF THE LAST CRUISE OF THE CARNEGIE. *Biology IV. Carnegie Institution of Washington Publication 555.*

By Herbert W. Graham, William Albert Setchell, Aaron L. Treadwell, et al. Carnegie Institution of Washington, Washington, D. C. $1.00 (paper); $1.50 (cloth). 11⅝ x 9; v + 129; 1943.

This work comprises a series of 8 papers (7 by separate authors; the 8th by several) covering the miscellaneous marine and land forms collected during the seventh cruise of the *Carnegie* in 1928–29. Two of the reports deal with floral collections of the expedition, while the balance are concerned with faunal forma. For the most part, the reports simply list the species of organisms studied or collected, together with a note on the occurrence, distribution, and the ecology of the various forms.

Because of our incomplete knowledge of the annelid fauna of the oceans, the paper on the polychaetous annelids is particularly significant and worthy of note. The value of these excellent collections is shown by the fact that of the 28 species studied, 15 are listed as new.

A majority of the papers carry brief bibliographies.

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SEASONAL EXPERIENCES IN BIOLOGY.

By Sister M. Anthony Payne. American Book Company, New York. 88 cents. 9¾ x 7¾; 251; 1943 (paper).

This laboratory manual was prepared primarily for use in conjunction with the author's recent text, *Biology Season By Season* (c.f. Q.R.B., vol. 18, p. 273). The method of presentation follows that of the text, namely, the various biological materials and principles are outlined for study during the season of the year with which they are most closely associated.

Many of the "Experiences" are simply lists of questions to be answered after reading the text. However, ample opportunity is provided for the high school student to obtain a working knowledge of the scientific method, as well as the substance and principles of biology. Particularly worthy of note is the last unit of the workbook, "The Health of Man," in which a number of common-sense health measures are stressed, and a series of cure-alls and health fads are debunked.

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UNIVERSITY OF COLORADO STUDIES. *Series D. Physical and Biological Sciences, Vol. 2, No. 1.* Containing the following papers: *The Vitamin B_1 Content of Colorado commercially canned tomato juice*, by Charles F. Poe; *The Vitamin B_2 Content of Colorado commercially canned tomato juice*, by Charles F. Poe; *Plant responses induced by certain chemical growth regulators*, by Edna Louise Johnson; *The effect of agricultural conditions on the mineral contents of some farm crops*, by Glen Wakeham; *Some ascomycetous foliage diseases of Colorado conifers*, by P. F. Shope; *An annotated list of the free-living Protozoa of Colorado*, by Luella Hamilton.

University of Colorado, Boulder, Colorado. $1.00. 10 x 6¾; 53; 1943 (paper).

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HUMAN BIOLOGY

ISLAND PEOPLES OF THE WESTERN PACIFIC: *Micronesia and Melanesia. Smithsonian Institution War Background Studies Number Sixteen. Publication 3737.*

By Herbert W. Kreiger. Smithsonian Institution, Washington, D. C. Free. 9 x 6; iv + 104 + 21 plates; 1943 (paper).

American interest in insular geography waxes and wanes with the economic tides. The distant South Pacific islands, almost forgotten since the days of the whaler and the guano ships, have again suddenly been brought into sharp focus. Before 1941, by steamship folder, motion picture, and travelog, we had been made aware of the existence of South Sea coral islands where cocoanut trees swayed in the balmy breezes of the southeastern tradewinds. We, as a people, knew very little of the realistic medical work of the International Health Division of the Rockefeller Foundation throughout much of the British Melanesian island world. Neither were we greatly concerned with the missionary activities of the several branches of the Christian church throughout the islands of the western Pacific. Equally unknown to most Americans is the degree of penetration of civilized law and the extent of its enforcement by Australian district officers throughout the controlled areas of New Guinea, New Britain, and New Ireland. Social scientists have noted with interest, and have profited by, the activities of the Australian National Research Council in furthering cultural studies of native Melanesians. As the author points out, in Melanesia, we are dealing with an exclusively French, British, and Australian island area, while in Micronesia, within historic times, the Spanish have, in turn, been supplanted by the Germans and the Japanese.

The strategic importance of the numerous island archipelagoes fanning out from Indonesia and the southeastern Asiatic coast was formerly as little appreciated by the British as by the Americans. The great marginal Melanesian island of New Guinea alone is 1,500 miles in length, almost the distance from New York City to Denver, while the Solomon Island archipelago from northwest to southeast stretches a total distance of 700 miles. Recent world developments have aroused our curiosity as to the Melanesian way of living. Then, too, the people of the United States are now definitely committed to an increasing interest in its island populations and coral atolls. Many of these islands are potential naval bases of possible use to the foe if not to an ally.

The present booklet contains a veritable gold mine of information about this all-important part of the world. The author discusses the discovery and early history of these islands and their picturesque inhabitants, and then he presents the geography patterns of culture and other pertinent information about each of the island groups comprising Micronesia and Melanesia. The concluding section on Micronesian and Melanesian prospects for the future is especially timely and interesting. The illustrative plates, representing some of the finest examples of southwestern Pacific photography, are real works of art and add immeasureably to the effectiveness of this presentation. There is a selected bibliography, but no index.

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Man: Real and Ideal. *Observations and Reflections on Man's Nature, Development, and Destiny.*

By Edwin Grant Conklin. Charles Scribner's Sons, New York. $2.50. 8 x 5½; xvii + 247; 1943.

In this book on the nature and prospects of man, Conklin touches on many topics—from kindness towards animals to the League of Nations, from the Millerites and the miracles of Lourdes to evolution and Christian ethics.

He discusses the species Man, and the scientific and social obstacles which limit man's ability to control his own future evolution through a positive program of eugenics. He turns then to the individual rather than the species and considers physical, mental and social development, and the part played by inherent mechanisms, environment, "creative synthesis" and purposiveness in these processes. After building up the developmental picture, he deals in the last chapters with the cultural values, science, religion, philosophy, and ethics, proper to man as portrayed from this biological standpoint.

The exposition is not always clear and consistent. For instance, in one place evolution and progress are identified; but following this a distinction is made between general evolutionary progress and specialization, and later on the possibility of retrogressive evolution is recognized. This confusion is due to the definition of progress as adaptation for survival, which fails to distinguish between adaptation to a restricted environment (specialization, sometimes retrogressive) and advances in organization which increase the range of habitable environment (progress).

It is not made clear whether the concepts of "the ethics of science" and "the religion of science" are considered as original contributions of science (or scientists) as such, or whether they are not rather adopted by scientists from the ethics and religion of Christianity. If the latter is the case, have we any right to claim that science in itself is a creator of values, a sponsor of religion and ethics? It is man as a human being, living in Christian or other humane traditions, who is their sponsor. The scientist, as a scientist, may select or modify, but he is inseparable from humanity and its traditions, whatever these may be. To speak of an "ethics of science," then, is only to say that scientists are, after all, human beings.

In so short a book it is too much to expect that many such points can be fully discussed. The reader, layman or scientist, is given ample scope for expansion and argument by a stimulating and provocative discourse.

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The North American Indian Today. *University of Toronto-Yale University Seminar Conference, Toronto, September 4–16, 1939.*

Edited by C. T. Loram and T. F. McIlwraith. The University of Toronto Press, Toronto. $3.15. 8½ × 5⅝; xi + 361; 1943.

This report is the result of the fifth of a series of conferences sponsored by the Carnegie Corporation of New York and conducted by the Department of Race Relations of Yale University. In this volume have been collected the contributions of 30 different authors—anthropologists, sociologists, officials, missionaries, traders, etc.—who are all concerned with the diversified problems of the past, present, and future of the 350,000 Indians in the United States and the 115,000 Indians in Canada.

Since the days of Columbus the contacts of the invaders and the aboriginals of North America have varied between war and peace, exploitation and protection, bitter hatred and cooperation until today the Indians have become a minority group still inadequately fitted into our social structures.

This welcome volume will greatly aid a more thorough and widespread understanding of the historical, social, and cultural factors which form the basis of present Indian life and will have to be considered in planning future policies. Several chapters dealing with Indian culture are followed by papers discussing the influence of traders and missionaries. One part of the book is devoted to governmental policies relating to Indians, another to the administration of law and order, and still another to Indian education. The problems of land and economics receive due attention and two papers discuss the arts and crafts of Indians. Of special interest to the biologist is the section on the health of the Indian. Here it is mentioned that infectious diseases, introduced by the whites, were far more effective in the early conquest of the Indians than were military measures. Tuberculosis is undoubtedly "the great Indian killer," the death rate from this disease being several times greater in Indians than in whites, but there is reason to believe that the former are gradually acquiring greater resistance against tuberculous infection. Infant mortality is still shockingly high among Indians, but cancer appears to be comparatively rare.

It is to be hoped that there will be more such productive conferences and that they will again be published in such instructive volumes.

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BURMA—GATEWAY TO CHINA. *Smithsonian Institution War Background Studies Number Seventeen.* (*Publication 3738.*)

By H. G. Deignan. Smithsonian Institution, Washington. Free. 9⅛ x 6⅛; iv + 21; 1943 (paper).

Occupying the northeastern third of the great peninsula of Indo-China or Farther India, the British dependency of Burma, with its subsidiary states, embraced, at the beginning of 1942, an area in excess of 261,000 square miles, only slightly less than that of the State of Texas. Protected against powerful and influential neighbors to north and west by imposing mountains which have acted as barriers to conquest, the civilization which arose on the fertile plains and deltas of the Irrawaddy, the Sittang, and the lower Salween rivers drew upon the cultures of both India and China, and yet, by its quasi isolation, developed into something distinct although analogous with the sister civilizations which appeared, under similar conditions, in Siam and Cambodia. Both culturally and geographically Burma is alien to China and India, but closely related to Siam and the former French territories.

The present excellent account gives us all the essential information about the Burma of yesterday and today, and a glimpse into the possible Burma of tomorrow. Throughout this booklet, an interesting distinction is drawn between *Burmese* and *Burman*, the former referring to all nationals of modern Burma, the latter only to its dominant people. Subject-matter discussed includes: geography, climate, health, natural products, fauna, peoples and languages, social life of the Burman, early history, the first, second and third Anglo-Burmese wars, and government. Particularly timely are the sections dealing with the development of nationalism in Burma and the relations between that country and Japan. There is a brief, but pertinent, discussion of the Burma Road. The author discusses in some detail the first battle of Burma, in 1942, and concludes the booklet with an enlightening presentation of the facts with regard to the so-called "co-prosperity sphere" of the Japanese. The beautifully reproduced photographic plates add much to the value of the pamphlet for the average intelligent reader, who, incidentally, will find much to interest and enlighten him in these pages. There is a selected bibliography, but no index.

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SELECTIVE FACTORS IN MIGRATION AND OCCUPATION. *A Study of Social Selection in Rural Missouri. The University of Missouri Studies, Volume XVIII, No. 2.*

By Noel P. Gist, C. T. Pihlblad and Cecil L. Gregory. University of Missouri, Columbia. $1.50. 10½ x 7¼; 116; 1943 (paper).

This study is based on a sample of 5461 persons, all of whom had been high school students in 97 rural Missouri communities between 1920 and 1930, most of them between 1923 and 1927. The status of these students in 1938 as to place of residence, occupation, and educational achievement is set against an index of their high school scholastic index, parental occupation, and certain other background factors.

The authors point out that the fact of attendance at high school involves a favorably selected sample from the population, and this must be kept in mind in interpreting the results. There is no indication of any other selection in the sample, and if this is the case, they were very successful in the percentage of persons located, only 148 out of the 5461 being unknown as to 1938 location.

This group shows a good deal of stability, with 35 per cent of the males and 33 per cent of the females having the same address some 12 years later as when they attended high school, 46 per cent of both sexes remaining in the same county, and 78 per cent of the males and 81 per cent of the females still residing in Missouri. In interpreting these figures, it must be remembered that the sample is one from rural and village high schools, not urban schools.

There are a number of associations shown between high school scholastic records and subsequent occupational and residence situations. In general, they show some positive correlation between scholastic standing and both distance moved and skill of occupation. Some of the factors behind these correlations and their social implications are discussed.

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UNDER A LUCKY STAR: *A Lifetime of Adventure.*

By Roy Chapman Andrews. The Viking Press, New York. $3.00. $8\frac{3}{4}$ x $5\frac{3}{4}$; 300; 1943.

This is the lively, informal, and purely descriptive autobiography of the well-known, and but recently retired, director of the American Museum of Natural History in New York. It is the narrative of a versatile, extrovert personality who started his career by sweeping laboratory floors and ended it 35 years later as administrative chief of the world's largest museum. The author's varied and successful activities as naturalist, explorer, and promoter have taken him through most the countries in and surrounding the Pacific Ocean, where he has spent a large part of his life. Much of the book deals with field experiences in the study of whales and on trips to Mongolia in quest of fossil vertebrates, exploits which have also been recorded in several previous books by the same author. Perhaps even more entertaining and extraordinary than some of the stories of happenings in strange countries among primitive people are the detailed accounts of the financial and diplomatic adventures connected with the author's expeditions on a grand scale. There is action and interest on every page, whether it describes the discovery of dinosaur eggs, the red-light district of Yokohama, the social organization of fur-seals, or the technique of fund-raising.

The book is intended primarily for the general public, but the vivid "confessions" will also interest greatly the many scientists who have benefitted by the results of the explorations of Andrews and his distinguished associates.

◆

ARCHEOLOGICAL INVESTIGATIONS IN PLATTE AND CLAY COUNTIES, MISSOURI: *With Appendix on Skeletal Remains from Platte and Clay Counties, Missouri*, by T. Dale Stewart. *Smithsonian Institution, United States National Museum Bulletin 183.*

By Waldo R. Wedel. U. S. Printing Office, Washington, D. C. $1.00. $9\frac{1}{2}$ x 6; viii + 284; 1943 (paper).

The data for this very interesting report were gathered by Wedel in the course of field work in Western Missouri during the summers of 1937 and 1938. Wedel deals mainly with two sites of the Kansas City area: the Renner site on Line Creek and the Steed Kisker site on Platte River, both inhabited before the arrival of white men. Wedel connects the Renner site with the stone chambered burial mounds on the bluffs east of the Renner site. He deals extensively with the distribution and typology of these burial mounds in the Upper Mississippi Valley. Steed Kisker site, itself, contained an extensive burial ground of the earth mound type. Wedel regards the Renner site as a marginal manifestation, basically of Hopewellian derivation, while Steed Kisker represents a local variant of late Middle Mississippi culture with strong Nebraskan influences (housesite). From the standpoint of temporal succession the Renner site is therefore regarded as earlier than Steed Kisker. Steward found marked morphological differences in the two skeletal series: the one from the stone chambered mounds and the other from the Steed Kisker burial ground. The Hopewellians seem to have inclined to relatively long and narrow faces and somewhat smaller stature. Both groups seem to have been afflicted with syphilis. Both series are remarkably similar to series from the same culture in other regions.

◆

CULTURE ELEMENT DISTRIBUTIONS: XXIII. *Northern and Gosiute Shoshoni. Anthropological Records, Volume 8, No. 3.*

By Julian H. Steward. University of California Press, Berkeley. $1.25. 11 x $8\frac{1}{2}$; iii + 263–392; 1943 (paper).

Following the usual methods of the *Culture Element Distributions* Series, Steward has checked 2933 traits among the Northern and Gosiute Shoshoni. He finds two cultural types among the seven groups studied: a northern type, possessing horses and having taken over numerous elements of plains culture; and a western type, lacking horses and showing a very impoverished culture, which is easily understood as the groups in question inhabit the most infertile parts of the Basin.

In contributing 25 pages of ethnographical discussion and 33 pages of ethnographic notes on the element list Steward has made his volume somewhat more substantial than were other numbers of the series, and makes it approach closer in character to a little monograph. In the discussion which emphasizes particularly hunting, shamanism, and dances, Steward partly takes up points already dealt with in earlier publications of his (especially BAE Bulletin No. 120, 1938: Basin Plateau Aboriginal Sociopolitical Groups) and partly brings up new points.

◆

ZOOLOGY

ANOPHELES GAMBIAE IN BRAZIL: *1930 to 1940.*

By Fred L. Soper and D. Bruce Wilson. The Rockefeller Foundation, New York. 9 x 6; xviii + 262; 1943.

Anopheles gambiae, a notoriously dangerous vector of malaria in Africa, succeeded in crossing the Atlantic Ocean and invading the northeastern portion of Brazil.

The present volume relates the progress of this invasion, the devastation wrought, the counter measures undertaken, the astonishingly rapid retreat of the invader, and its final elimination. It is a fascinating story to those interested in the epidemiology and control of perhaps the number one disease of this universe.

Although transatlantic air transportation between Dakar and Natal had already begun in 1930, it is not believed that the original crossing of *A. gambiae* occurred by this route. It is suggested that it came over as a stowaway aboard one of the fast French destroyers during a mail run that required less than 100 hours. The presence of the African mosquito in South America was first discovered by R. C. Shannon in March, 1930. At that time it had established only a small beachhead at Natal. There was almost an immediate increase in malaria at Natal, but no counter measures were undertaken until a relatively severe epidemic occurred in 1931. On that occasion some 10,000 cases were reported at a worker's suburb of Natal with a population of 12,000. With aid from the federal government, the Yellow Fever Service and later the State Health Department succeeded in eliminating *gambiae* from Natal.

Unfortunately when this work was abandoned at Natal, the mosquito had already penetrated deeper into the country. The topography of the region and droughts hampered its progress, but man-made ditches and shallow wells tended to offset these obstacles. For five years, 1932 to 1937, *gambiae* attracted very little attention to its presence and caused no serious consequences. However, during this Silent Era, it was gradually invading the generally non-malarious valleys of the Assú and Apodí rivers in Rio Grande do Norte and the Jaguaribe River in Ceará. Then in 1938 a fulminant epidemic of malaria occurred in these valleys that shocked the authorities into a realization of the seriousness of the situation:

> The human language is far from adequate to describe the desolation which existed in the region, in which suffering, tears and mourning spread their lugubrious mantle over thousands of graves. The general belief was that the Northeast would be depopulated because those who did not die at once would abandon it (*Gazeta de Noticias*, Fortaleza).

With funds from the Brazilian government and the Rockefeller Foundation, the Malaria Service of the Northeast was organized and started operations in January, 1939. Due to the lack of definite concrete techniques that would guarantee the eradication of *gambiae*, little material progress was made during the first six months. During this hectic period, many control methods were instituted—filling, oiling, paris green dusting, pyrethrum spraying, and drug treatment. Later the Service concentrated on applying paris green to the breeding places to destroy the larval stages and the wholesale spraying of houses to kill the adults. The limits of *gambiae* distribution were soon determined and all vehicles and planes were carefully disinsectized before leaving the area. The last six months of 1939 revealed that control was effective and that a noticeable reduction of the infected area had occurred. Later, it was heartening to observe that *gambiae* failed to reappear following suspension of control activities in a few selected areas. By January, 1941, confidence in the eradication was so strong that a reward of ten days pay was offered to any employee finding a specimen anywhere in Brazil. Even though the reward was later doubled, no claims were made. Most of the control activities were suspended shortly after that time, but a skeletal organization of the Malaria Service of the Northeast is still maintaining a constant vigilance to detect reappearances or reintroduction of this mosquito. The success of this program is not only praiseworthy for the service rendered to a disease stricken region, but is acclaimed for demonstrating the efficacy of species eradication for the control of malaria.

BIOLOGY OF ACARUS SCABIEI.

By Reuben Friedman. Froben Press, New York. $3.00. 9 x 6; 183, 1942.

The outstanding feature of this book is the long series of photographs of figures from original works on mites. There are in all 112 illustrations, 58 of which are full page photographs. Friedman's main contribution is the series of 32 photomicrographs. Those of the individual mites and of some of the burrows with eggs and larvae within are excellent.

The book is divided into three chapters. Chapter I, entitled "Observations concerning mites in general and the itch mites in particular" is the least noteworthy part of the book. For example, Banks' (1915) work on *The Acarina or Mites* is quoted to indicate the importance of mites. Most of our knowledge of mites and ticks in relation to such diseases as Rocky Mountain Spotted Fever, Tsutsugamuchi, relapsing fever, tularemia, tick paralysis, etc. is more recent and fully as impressive as the mentioned cattle tick fever which has been all but eliminated in this country.

When the statement is made that "the number of species of mites, however, is not as numerous as one might expect," many readers unfamiliar with the field of Arachnology will assume that there are not many species of mites. It is quite likely that the greater number of species of mites, both free-living and parasitic forms, are yet to be described. The smallness in size and the difficulty in handling have made the mites difficult subjects on which to work. This difficulty is reflected in Chapter II of the book, entitled "Early knowledge of *Acarus scabiei*." It occupies 93 pages of text and photographs pointing out the contributions of different workers in the study of the morphology and life history of the itch mite. Such outstanding works as those of De Geer, Gervais, Kraemer, Simon, Lanquetin, Robin, Furstenberg and others are discussed and copies of their drawings included.

In Chapter III, "Modern knowledge of *Acarus scabiei*," the more recent contributions on the morphology and life history are discussed. Here the very important works of Munroe in his "Report of scabies investigation," published in the *Journal of the Royal Army Medical Corps* in 1919 and of Buxton and Warburton in *Parasitology* in 1920 and 1921 are considered.

Most of the publications used in the preparation of the book are found in only a few of the larger libraries of the country. One item alone, the figures from Buxton's paper "The external anatomy of the Sarcoptes of the horse" and the accompanying discussion is worth more than the cost of the book since the original paper is no longer available except from book dealers.

It would seem that the book is of greater value to the student of mites than to the physician who wishes to recognize the disease and to treat it. Although dealing with the biology of the mite, the book does not give an indication of the number of organisms usually found on the patient. Mellanby in 1943 in one of the Oxford War Manuals entitled *Scabies* shows that the number of mites found on the individual is not great. He also points out that the original infection is hard to detect since the symptoms of the disease probably represent an immune response on the part of the host.

An error in typesetting is apparent at the top of pages 99 and 103 where the caption should read "Early knowledge of *Acarus scabies*."

The reviewer would have preferred that the name Sarcoptes appear in the title of the book as in the table of classification on page 8. To most physicians, as well as students of mites, the itch mite will still be commonly thought of as Sarcoptes.

◆

FOOD FROM THE SEA: *Fish and Shellfish of New England. United States Department of the Interior, Fish and Wildlife Service, Conservation Bulletin No. 33.*

By Rachel L. Carson. Government Printing Office, Washington. 15 cents. 9⅛ x 5¾; 74; 1943 (paper.)

FISHES OF THE MIDDLE WEST. *United States Department of the Interior, Fish and Wildlife Service, Conservation Bulletin No. 34.*

By Rachel L. Carson. Government Printing Office, Washington. 15 cents. 9⅛ x 5¾; 44; 1943 (paper).

These two pamphlets are important for the layman as well as the amateur and professional fisherman. Written by Rachel Carson, Aquatic Biologist of the Government Division of Fishery and Biology, and issued by the Fish and Wildlife Service for a nominal sum, they are authoritative and timely.

Very nearly all forms of fish and shell fish that come on the market from the two regions are discussed by Carson. The reader is introduced to forms which he has only vaguely heard of in the past. Many available fish, not well known, but of real delicacy of flavor and highly esteemed by the epicure, do not find their way to market in quantities because of lack of consumer demand.

> For every one of the ten fish or shell-fish that make up more than four-fifths of New England's catch there are seven species little known or utilized, many of which could provide tasty and nutritious foods. Turning to these under-utilized species will conserve food resources by lifting the burden of overexploitation from such fishes as cod and haddock and will augment dwindling supplies of protein foods.

Among the fish catches of the Middle West are also many discarded fishes of excellent food quality.

Aside from giving information concerning the abundance of the different types of fish, their nutritive value, life history, and distribution, the author has included much general information which makes interesting reading. There are curious regional prejudices about fish. The whiting, considered of little value in New England States in whose waters it abounds, is "one of the best known and most widely used of New England fishes in sections of the middle west." Of the carp, we read "Because most of the carp of the Middle West have been shipped to specialized markets in such eastern cities as New York, Boston, and Philadelphia, many people, even in the chief carp-producing states such as Illinois and Minnesota, are totally unfamiliar with its possibilities as a food fish."

Both pamphlets conclude with well-selected bibliographies.

◆

STUDIES IN THE MORPHOLOGY, TAXONOMY, AND ECOLOGY OF THE PERIDINIALES. *Biology III. Scientific Results of Cruise VII of the Carnegie during 1928–1929 under Command of Captain J. P. Ault. Carnegie Institution of Washington Publication 542.*

By Herbert W. Graham. Carnegie Institution of Washington, Washington, D. C. $1.50 (paper); $2.00 (cloth); 11⅝ x 9; v + 92; 1943.

The scope of the scientific data collected on the last world cruise (1928–1929) of the nonmagnetic research vessel, *Carnegie*, of the Department of Terrestrial Magnetism, Carnegie Institute of Washington, included terrestrial magnetism, terrestrial electricity, chemical oceanography, physical oceanography, marine biology and marine meteorology. The present work covers a small portion of the marine biological collections, dealing specifically with 29 representatives of the order Peridiniales of the plankton samples taken from the Pacific and north Atlantic Oceans. Six new species, three new varieties, and six new forms among five families are described.

Since type specimens of the peridinians usually cannot be preserved, it was necessary that the forms be measured, studied, classified, and illustrated from microdissection of the fresh specimens. The study is an excellent exhibition of the use of quantitative biology (measurements of a number of morphological characteristics in a large series of individual organisms) for taxonomic categorization.

In addition to the morphological and taxonomic phases of the work, there is included an analysis of each form in relation to such ecological conditions as temperature, salinity, hydrogen-ion concentration, and phosphate content. Although it was found that the geographic distribution of the various species of Peridiniales is closely associated with temperature, no such association was found between distribution, and chemical composition of the water.

Numerous tables and charts are used to present the pertinent facts of the study. An index of scientific names is provided.

A GUIDE TO BIRD WATCHING.

By Joseph J. Hickey. Oxford University Press, New York. $3.50. 8⅜ x 5½; xiv + 262; 1943.

There has long been a need in this country for an authoritative guide to bird study. Hickey has fulfilled the need in this well-written and highly entertaining book. While primarily intended for the amateur and beginner, the entire field is so ably covered, including much original data, that the advanced ornithologist will also profit by its use.

The first chapter is for the beginner, explaining how and where to find birds, how to identify them, methods of studying their song, notetaking, binoculars and other items. The second chapter is devoted to migration, the problems still to be solved, and the most profitable methods for their resolution. Following are chapters on populations (estimate of numbers, densities, cycles, breeding censuses), on distribution (food, cover, habitat preferences, life zones, and biomes), on bird banding, and lastly on the art of bird watching which, as the author puts it "is the art of discovering how birds live," and not the "Field Card School of Ornithology" which is justly disparaged.

A set of five appendices complete the book. These are, however, just as useful as the main context. The first is an introduction to the study of bird tracts, a topic rather unique in bird work. Most of the data is new, being derived from the notes of the late C. A. Urner. The second appendix is entitled "Some results of breeding bird censuses," and the third gives an outline for life history studies. This outline takes up 13 pages of questions which a comprehensive study should endeavor to answer. This is one of the best features in the book and should prove a handy guide to observers. The last two appendices contain a list of selected readings and references, and a geographical annotation of the bird clubs in the United States and Canada. A most useful book, heartily recommended to all bird students.

INTERNATIONAL BOARD OF INQUIRY FOR THE GREAT LAKES FISHERIES. *Report and Supplement.*

United States Government Printing Office, Washington, D. C. 30 cents. 9¼ x 5⅞; iii + 213; 1943 (paper).

Records of the yearly fish catch on the Great Lakes have been made for many years—for Canada, yearly, beginning in 1867; for the United States (earliest record in 1879), regularly each year since 1913. Many boards and joint commissions in the past have investigated the fisheries in the contiguous waters of the two countries and have proposed regulations to protect the fish industry, but these regulations seemed to have received little attention. No satisfactory conservation program has ever been fully developed. The most recent of these boards, the International Board of Inquiry, was established in 1938 with a Scientific Advisory Committee from both countries. The present report is the work of this Board. It reviews, for each lake as a whole, statistics on the "take" for each species, the fluctuations of the take, depletion of stock, effectiveness of planting, etc.

In a supplemental report, which takes up the larger part of the volume, the United States members of the Board discuss, from the point of view of this country, the present fisheries for each lake, changes in production, recommendations made by commercial fishermen of the United States, and fishermen's views on administration and control of the fisheries. A general summary and a list of recommendations form part of the report. In a group of appendixes additional information is given concerning questionnaires sent to fishermen, sources of statistics, and a selected bibliography of the Great Lakes, their fishes, and fisheries.

The committee believes that a successful solution to the fishery problems of the Great Lakes can be found which will be as successful as have been those international agreements between the two countries which have been made for the restoration of the Pacific halibut and salmon and the migratory birds.

HANDBOOK OF SALAMANDERS. *The Salamanders of the United States, of Canada, and of Lower California.*

By Sherman C. Bishop. Comstock Publishing Company, Inc., Ithaca. $5.00. 9¼ x 6⅛; xiv + 555; 1943.

All the species and subspecies of salamanders known to occur in the United States, Canada, and Lower California are described in this handbook, third in the series under the editorship of Albert Hazen Wright. This is by far the best available all around publication on a most interesting, but still comparatively little known, group of vertebrates. Previous works have been either strictly taxonomic or else restricted in geographic scope. All of the 126 forms are described in the text with the following data: type locality, range, habitat, size, description, color, sexual differences, and breeding.

n addition each is illustrated by photographs of dorsal nd ventral views. The ranges are drawn on 56 outline maps, a valuable adjunct to be found nowhere else. These maps, as the author suggests, should indicate in many instances where profitable studies may be prosecuted. To aid in identification there are keys to the amilies, genera, species and subspecies.

In the introductory part the author gives a brief ésumé of the biological background of salamanders, heir behavior and relationships, where to find them, methods of collecting and preserving. All of this material has been condensed in about a dozen pages; he usefulness of the book would have been greatly ncreased had this part been somewhat more extended, but this slight objection is offset by the extensive bibliography of 76 pages, subdivided as to subject and geographical areas.

* * *

TYROGLYPHID MITES IN STORED PRODUCTS. *I. A Survey of Published Information.*

By M. E. Solomon. His Majesty's Stationery Office, London. 9d. net. 9⅝ x 6; iv + 36; 1943 (paper).

The aim of this brief but useful survey of the tyroglyphid mites "is to provide a guide and an introduction to the extensive literature, much of which is very valuable, but scattered and disconnected." To the Tyroglyphids belong, among other forms, the mites commonly known as "cheese" or "flour mites." The eggs and larvae of these mites are barely visible to the naked eye while the adult is only between 0.5 to 1.0 mm. in length. In stored products some of the Tyroglyphids can become very serious pests.

The material is arranged according to subjects. For example, under the heading "Bio-Ecology" the discussion is as follows: (i) Occurrence, (ii) Means of distribution, (iii) Parasitism, (iv) Medical and veterinary, (v) Natural enemies. With each topic discussed reference is given to the works of those who have made significant contributions in the field. Concluding the survey is a list of 227 titles. This list of references is incomplete, in that works which are repetitive or of little value have been omitted.

* * *

TERMITES (ISOPTERA) FROM THE AUSTRALIAN REGION *(Including Australia, New Guinea and Islands South of the Equator between 140°E. Longitude and 170°W. Longitude).*

By Gerald F. Hill. Commonwealth of Australia, Government Printer, Melbourne. 3s. 9¼ x 6; 479 + 24 plates; 1942.

Nearly 200 species of termites are described under the following headings: general description, measurements, distribution, biology, affinities and location of type material. When known, both winged adults and soldiers are included in the descriptions and in the illustrations which picture dorsal views of the head and pronotum. Many of the nomenclatural difficulties encountered in this group have been cleared up by the writer's extensive study of a large number of specimens. In the better known forms, the section dealing with biology contains much useful information on their habitats, nests, reproduction, and the type and amount of destruction incurred. Several plates show various types of termite nests and mounds. The area encompassed in this work includes Australia, New Guinea and islands south of the equator between 140°E. longitude and 170°W. longitude.

* * *

ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Vol. XXVIII, Part 2, Numbers 9–14.*

New York Zoological Society, Zoological Park, New York. 75 cents. 10½ x 7; 53–108 + 7 plates; 1943 (paper).

This number contains the following papers:

Physical factors in the ecology of Caripito, Venezuela, by William Beebe (2 plates; 5 text figures); On the locomotor and feeding behavior of certain postlarval Clupeoidea, by C. M. Breder, Jr. and Louis A. Krumholz (2 plates; 3 text figures); A revision of the subfamily Estrildinae of the family Ploceidae, by Jean Delacour (1 text figure); The relationship between weight and body form in various species of scombroid fishes, by Sidney Shapiro (12 text figures); A record of the successful breeding of the Quetzal (*Pharomachrus mocinno costaricensis*) in captivity, by Charles Cordier; The occurrence of leeches, *Ozobranchus branchiatus* (Menzies), on fibro-epithelial tumors of marine turtles, *Chelonia mydas* (Linnaeus), by Ross F. Nigrelli and G. M. Smith (3 plates).

* * *

THE NORTH AMERICAN PARASITIC WASPS OF THE GENUS TETRASTICHUS—*A Contribution to Biological Control of Insect Pests. Proceedings of the United States National Museum, Volume 93, No. 3170.*

By B. D. Burks. Smithsonian Institution of Washington, Washington, D. C. 9⅝ x 6; 505–608; 1943 (paper).

The genus *Tetrastichus* includes a large number of small chalcid-flies, parasitic or hyper-parasitic on a wide variety of hosts. Some of the latter include the Hessian fly, the cotton bole weevil, thrips, aphids, midges, leaf miners, scales, borers, roaches, beetles, and injurious gall makers. For this reason the genus is important economically and a thorough analysis of the taxonomy and nomenclature is desirable. Following a key to the species, there are complete descriptions of male and female, the distribution, and hosts. Twenty-three new species are described. A host list and the names of unidentifiable species follow the formal descriptions.

Summary of the Collections of Snakes and Crocodilians Made in Mexico Under the Walter Rathbone Bacon Traveling Scholarship. *From the Proceedings of the United States National Museum, Volume 93, No. 3169.*

By Hobart M. Smith. Smithsonian Institution, Washington, D. C. 9⅝ x 6⅛; 393–504 + 1 plate; 1943 (paper).

The present list is based largely upon the specimens collected by the writer under the Bacon scholarship. Included with this annotation are Mexican specimens of snakes and crocodiles already present in the National Museum's collections. Collecting localities are given for all specimens, tables of scale counts are given for those species with wide variation in these morphological characters, and several new subspecies are described.

BOTANY

The Virgin Upland Forest of Central New England. *A Study of Old Growth Stands in the Pisgah Mountain Section of Southwestern New Hampshire. Harvard Forest Bulletin No. 21.*

By A. C. Cline and S. H. Spurr. Harvard Forest, Petersham, Massachusetts. 50 cents. 9¼ x 6; 58; 1942 (paper).

This technical bulletin, like others in the series, adds valuable information in the field of forestry and sylvaculture. It presents the results of intensive studies of old growth stands undisturbed by man and located in the tract of twenty acres of the choicest virgin forest acquired by Harvard University in 1927. This tract in the Mt. Pisgah section, in the extreme southwest corner of New Hampshire, is a rough and hilly area ranging from 700 to 1300 feet above the sea, with steep slopes, swift streams, thin soils of the podzol type, a precipitation of thirty-eight inches and a growing season of 120 days. The comprehensive and detailed studies on which this bulletin is based were fortunately carried on chiefly in 1929–30 in the Harvard tract and in other tracts in the same general area before the New England hurricane of September, 1938, almost entirely destroyed the stands of old growth.

In these intensive studies thirty-eight plots in the old growth, and twenty-three in old growth recently cut over, were tallied, the tree cover was analyzed by height levels, density, vigor, age, topography, and soil, with additional data on the accompanying shrubs and herbs. The effect of such disturbing influences as fire, wind and ice-storms, insects, and fungi are considered, as are the ecological aspects from the point of view of the successions following from the pioneer and pre-climax stages up to the climax association. The value of the study can be appreciated through realizing that here was adequate record of a climax association reached in about 400 years during which no severe disturbance had interfered with the ecological successions.

The illustrations comprise twelve figures, chiefly excellent photographs well depicting the character of the different associations, with effective diagrams, tables, and charts, the five appendices showing in tabular view the composition of simple plots, the frequency of occurrence of tree species, and of shrubs and herbs, and the soil profiles under different stands. A bibliography of 1½ pages presents the pertinent literature.

The material presented here is not only of scientific interest for its detailed investigation of old stands now passed, but also of practical application, in that ecological analyses such as these, through enabling us to understand the sequence of successional stages and the nature of the climax forest ultimately resulting, give a sound basis for practicing sylvaculture in harmony with natural forces.

Edible Wild Plants of Eastern North America.

By Merritt Lyndon Fernald and Alfred Charles Kinsey. Idlewild Press, Cornwall-on-Hudson. $3.00. 8½ x 5½; xiv + 452; 1943.

Nature lovers who like to experiment with wild foods will find *Edible Wild Plants of Eastern North America* a worth while contribution to their library. Those who are not already acquainted with the numerous edible plants native to this region will find that there is an astonishing array of possibilities. To be sure, the value of wild fruits such as cherries, blackberries, and huckleberries, of pot herbs such as lamb's-quarters and pokeweeds, and of starchy vegetables such as the Jerusalem Artichoke are already well known. However, there are numerous lesser known sources of interesting foods which can be used to supplement the cultivated varieties, and the better known wild ones. Indeed, it is possible for a person who knows edible wild plants to sustain himself for a long time, perhaps indefinitely, away from civilization. Many of the plants listed fall into the category of emergency foods, for example, the inner bark of pines and elms. These may not be particularly appetizing, but they will sustain life. Others, such as cat-tails and certain acorns furnish abundant and appetizing food.

All edible flowering plants and ferns, and some of the more important mushrooms, lichens, and sea weeds occurring in the region east of the Great Plains, south of Hudson Bay, and North of Peninsular Florida are included. Many are illustrated. Related plants in other areas should be worthy subjects for experiment. The authors have made extensive use of a great number of the plants which they describe. In addition they have drawn upon the experience of others, including those of early settlers in the area covered by the book.

Because there are some poisonous plants which might be confused with edible ones, a complete chapter is devoted to these. There is also a classification of plants according to use. Most of the book, however, is devoted to a detailed enumeration and description of edible flowering plants and ferns which are arranged under families according to the system used in most herbaria throughout the nation. Methods of preparing them for food are included. The book is well indexed and there is an extensive bibliography.

In these times when food is expensive and at a premium, wild plants, many of which are undesirable weeds, can be utilized as a wholesome and interesting supplement to a diet restricted by the demands of war. *Edible Wild Plants of Eastern North America* tells what to use, where to find it, and how to use it.

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Burning an Empire: *The Story of American Forest Fires.*

By Stewart H. Holbrook. With a Foreword by Colonel William B. Greeley. The Macmillan Company, New York. \$2.50. $8\frac{3}{8}$ x $5\frac{5}{8}$; xiv + 229; 1943.

In his usual vivid, dramatic, and sometimes lusty style, the author tells the tragic tales of the historic forest fires in America, from the great Maine and New Brunswick conflagrations to the terrible Tillamook fire in 1933, in Oregon, which destroyed twelve and one half million feet of lumber—a year's supply for the entire United States. Mr. Holbrook, who has known about forest fires at first-hand for many years, has done a tremendous amount of painstaking research, and has rendered an invaluable service to American forestry. Step by step, he describes the progress in the methods of fire-control, the present experimental use of chemicals, the theory of relative humidity, and discusses such important aspects as the changes in forest types, the effects of fire on wild-life, and the general problems connected with controlled burning, and the re-stocking of fire-killed acres.

The American Forestry Association, founded in 1875, has been in the front rank of conservation leaders ever since the group launched a campaign, in 1882, for forest protection and management. Credit is given to the late Civilian Conservation Corps, which was started in 1933, and gave fire-control work the first large body of men it ever had. Today, in the United States there exists the greatest forest protective force on earth, but that is not enough. Unless Americans as a whole change their habits, which carry over from the negligence and indifference of pioneer days, we shall always have the greatest of all forestry problems with us. Absolute prevention of forest fires will come only after continuous education, with particular emphasis on the younger generations.

Mr. Holbrook's forceful style and graphic presentation of the stark tragedy and havoc accompanying forest fires leaves no doubt in the reader's mind of the seriousness of the need for fire prevention, yet he relieves the tension which such descriptions must necessarily create by moments of picturesque humor. The last chapter of this extremely interesting and authoritative book includes several little-known ballads of forest fires.

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Diseases and Pests of Ornamental Plants.

By Bernard O. Dodge and Harold W. Rickett. The Jacques Cattell Press, Lancaster. \$6.50. 9 x 6; xi + 638; 1943.

Diseases and Pests of Ornamental Plants is designed for use by gardeners, not all of whom have a technical knowledge of botany and entomology. Hence, although the scientific names of fungus parasites and animal pests are included, the book is not written in highly technical terms. The descriptions and explanations are clear and adequately supplemented by illustrations.

The first four chapters are introductory in nature. There is a classification of plant diseases according to symptoms and one according to causes. Disease symptoms are described and illustrated. A chapter is devoted to bacteria and fungi, in which life histories and diagnostic characters are presented. Comparable treatment is given the insects and other animal pests. However, the section on fungi and insects is of necessity brief, and references for those who desire further information are given under "Acknowledgments." The chapter on control measures includes sanitation, the uses and effects of poisons, equipment, the use of disease resistant varieties, and biologic control.

The major portion of the book is devoted to a cataloging of the diseases and pests of particular hosts. The selection of hosts is based upon the New York Botanical Garden collection. All of the important ornamentals of the United States are included. Host plants are listed alphabetically under their generic names. Some plants will be found to be afflicted with few diseases and attacked by few animal pests. Others, such as *Chrysanthemum* are subject to attack by nearly a dozen fungous diseases, a dozen or more insect pests, red spider mites, nematodes, and termites. In such cases methods of recognizing and controlling each parasite are given.

Diseases and Pests of Ornamental Plants is both extensive and up-to-date. It should be welcomed by all who are interested in the cultivation of ornamental plants.

MORPHOLOGY

Body Poise.

By Walter Truslow. Williams and Wilkins Company, Baltimore. \$4.50. 9 x 6; ix + 312; 1943.

It scarcely need be emphasized that proper body poise is an essential of physical fitness, nor that too few individuals have any real understanding of the essentials of correct posture. This treatise by an experienced orthopedic surgeon and student of the subject will be of interest and value to medical man and layman, and can be read with profit by both.

The first part of the book, dealing with the anatomy and physiology of postural components (skeleton, joints, muscles) will be hard going for other than those with training in biology or medicine. The neurological aspects of posture regrettably receive no mention. Analysis of the action of individual muscles is far more satisfactory, however, than that found in many anatomical texts.

Some pathological deviations from normal posture—as flat fleet and spinal curvatures—are dealt with in Part II. The discussion of their treatment and prevention forms one of the most useful portions of the book.

The concluding section is devoted to a consideration of body poise as related to games and sports. One notes that the author regards walking, swimming, running, basket-ball, diving, skating, skiing, canoeing, sculling, row-boating, horse-back riding and broad-jumping as having little or no tendency to produce incorrect posture; crew-rowing, golf, boxing, football, hockey, tennis, bicycling and fencing as having a mild tendency to cause faulty body poise; and baseball, archery, and such track-and-field events as hurdling, high-jumping, pole-vaulting, shot-putting, discus-throwing and javelin-throwing as possessing a greater tendency toward the production of poor posture through disproportionate and asymmetrical development.

An index and a glossary of technical terms are appended. Such a glossary is of use only to the layman, and hence to be of any value must be accurate. In this instance it defeats its purpose, for it is replete with misspellings and inaccuracies. To cite only a few instances, M. semimembranosus and M. semitendinosus both are misspelled (as they are throughout the book, and this with complete impartiality toward any particular variant); M. gracilis is not, as stated, the longest muscle in the human body; and the medulla oblongata is not, as indicated, the upper part of the spinal cord. The use of antiquated, superseded names for many muscles (e.g. "complexus" for semispinalis capitis, "extensor ossis metacarpi pollicis" for abductor pollicis longus, "trachelo-mastoid" for longissimus capitis, and "triangularis sterni" for transversus thoracis), a practice so strangely beloved by surgeons, can only be deplored.

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MICROSCOPIC TECHNIQUE IN BIOLOGY AND MEDICINE.

By E. V. Cowdry. The Williams and Wilkins Company, Baltimore. $4.00. 9 x 6; 206; 1943.

Cowdry's microscopic technique is unique among books in its field in giving the information under subject and author headings in alphabetical order. This book has the advantage that any particular information is found quickly. It is thus not a textbook or introduction to microscopic technique, but a conveniently ordered collection of a multitude of special techniques for the many particular problems of modern microscopy. Emphasis is laid upon recent developments which promise to put microscopic technique on a more scientific basis than it has been in the past. One can only agree with the author that

> . . . some of us individually are still extraordinarily conservative in the methods we use. The possibilities of improving old techniques, of replacing some of them by new ones and of relying more upon microchemical and physical procedures are not explored as they should be. The purpose of this book is to extend the horizon by exposing in an introductory way a few of the many opportunities awaiting workers in biology and medicine interested in the minute structure of living things.

The amount of information contained in the 206 pages of the handy volume is truly astonishing. Yet the treatment of the subjects is often uneven and the selection appears sometimes arbitrary. Not rarely one finds instead of an answer a mere reference to some article or book. Even more disappointing, however, is it to find in a book stressing recent advances mitosis defined as "indirect nuclear division in which the chromatin forms a thread which breaks up into chromosomes." It is now time to get rid of this notion disproved years ago.

Of great value is the introductory chapter which forms a concise review of the most important techniques used today in the study of the minute structure of living organisms. It serves as an excellent introduction to the possibilities of modern methods.

Cowdry's book does not replace handbooks of microscopic technique like Lee's *Vade-Mecum*. But it is used to great advantage as the first step in seeking information on a particular subject and very often the answer is found right here, saving a laborious search in more voluminous treatises. On the whole it is a fine contribution to the education of the general microscopist.

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FINGER PRINTS, PALMS AND SOLES. *An Introduction to Dermatoglyphics.*

By Harold Cummins and Charles Midlo. The Blakiston Company, Philadelphia. $4.00. 9 x 6; xi + 309; 1943.

The specialized skin of our palms and soles bears fine ridges, arranged in intricate patterns, called dermatoglyphics. These configurations are formed early in fetal development and persist unchanged throughout life. The combinations of the detailed variations in dermatoglyphics are never precisely alike in any two individuals, hence they afford a unique basis for personal identification. These variations show different trends in human races, in the two sexes and among constitutional types. The broad biological significance and practical usefulness of dermatoglyphics is evident also from the facts that the pattern of skin ridges on palms and soles have been studied extensively in connection with problems appertaining to bodily symmetry, twinning, human heredity, disputed paternity, etc.

The two authors of this volume have recently published another book in which they described the dermatoglyphics of monkeys and apes and discussed the phylogeny of these structures in man (*Palmar and Plantar Dermatoglyphics in Primates, Philadelphia,* 1942). The present, condensed treatise has for its main purpose the collection of the most significant information relating to this comparatively neglected phase of human biology—the detailed construction of man's palms and soles. After a brief historical introduction the general nature of skin ridges is described. This is followed by a lengthy section devoted to the exacting technique of recording and interpreting dermatoglyphics. The second half of the volume deals with the biological aspects of the subject matter, chiefly from the point of view of comparative anatomy, embryology, genetics, and racial, as well as constitutional, differentiation. It is to be regretted that the usefulness of the book is limited on account of the lack of conclusions or of anything serving as a summary. Even though the sum total of our knowledge of man's dermatoglyphics is still quite inadequate, it would seem possible to draw at least some tentative, general conclusions, to serve as foundation or scaffolding for future work.

The book closes with a carefully prepared, classified bibliography of 361 titles and with an adequate index.

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MANUAL OF COMPARATIVE ANATOMY.

By Osmond P. Breland. McGraw-Hill Book Company, New York and London. $2.00. 8¼ x 5¼; ix + 250; 1943.

This is a laboratory manual designed for a course, conducted in the traditional manner, dealing with types rather than with systems. *Amphioxus*, lamprey, dogfish, perch, *Necturus*, turtle and cat are the "types." More time is allotted to study of dogfish and cat than to any of the other forms. Nothing fundamentally new in the way of pedagogy or point of view is contributed. The student still is asked to dissect out and memorize the traditional long list of feline muscles, and it is not to be wondered if he asks "why?" Likewise, as is usual in most courses of comparative anatomy, the nervous system is dealt with all too inadequately. Thus, to take the treatment of the spinal nerves of the cat as an example, the student receives no real idea of their morphology and distribution. The directions for dissection and study of the limb plexuses suggest a lack of understanding of these structures on the part of the author—why have the student identify the femoral, peroneal and tibial nerves, yet omit the obturator? These *four* are the essence of the lumbosacral plexus. Only 14 lines are devoted to the mammalian autonomic system, although this perhaps can be forgiven in view of its difficulty of dissection by a beginner in so small an animal as a cat. In the experience of the reviewer, students generally come through courses in comparative anatomy with less real understanding of the nervous system than of any other part of the body. This does not result entirely from the difficulties intrinsic to the subject. Rather, it is due largely to the fact that, since comparative neurology virtually has become a special branch of science, most comparative anatomists possess but slender knowledge of the nervous system, and this is reflected in their teaching.

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ANATOMY OF THE DOGFISH.

By E. L. Lazier. Stanford University Press, Stanford University. $1.25. 9 x 6; vi + 110; 1943 (paper).

This is a combined text and laboratory guide. The whole anatomy is covered both comprehensively and succinctly, with emphasis upon development and function. One obtains the feeling that the author not only has a thorough and scholarly knowledge of his subject but an understanding of the student's requirements and point of view as well. It is a real contribution to the teaching literature of comparative anatomy. Unfortunately, there is no index.

PHYSIOLOGY AND PATHOLOGY

ALLERGY.

By Erich Urbach and Philip M. Gottlieb. Grune and Stratton, New York. $12.00. 10 x 6⅞; xxii + 1073; 1943.

The growing interest in allergy and in its relations to the entire field of medicine is reflected in the increasing number of publications on this subject, ranging from small manuals to voluminous treatises. Urbach's text belongs to the latter category and has attempted to give a complete report on our theoretical and practical knowledge in this still disputed and vaguely defined section of medical science. A book of this type, of course, could not serve well as an introductory textbook for students desiring guidance and solid ground for their information. The specialist, however, will be thankful for the very thorough covering of the whole subject, and particularly for the very numerous references, especially from the less accessible European literature. But even he might feel that desire for completeness can be overdone and that a more discriminating discussion which disregards publication of doubtful and unconfirmed value would make the book more readable and helpful.

American allergists have been reluctant so far to accept the introduction of new terms like pathergy, metallergy, and parallergy which have been coined by European workers, and it remains to be seen how convincing Urbach's efforts will be to establish their legitimacy. The discussions of such, and other theoretical, subjects in the book unfortunately suffer from a lack of clarity and from a certain vagueness and inaccuracy in the author's style and thinking. The chapters on pathology and chemistry of allergy are particularly unsatisfactory in this respect. A quotation from p. 673 (pathogenesis of bronchial asthma) may illustrate this point: "The swelling of the mucous membranes gives rise to an increase in secretion, with the result that a viscid secretion is formed...." The section on etiologic agents of allergic diseases, though very extensive, is not so well organized and not so complete as in some other well-known textbooks on the subject. As to treatment, the author devotes much space to oral therapy, recommending his propeptans, but also oral administration of autogenous vaccine and autogenous dust. His "working hypothesis" and the experimental data supplied in support of the propeptan therapy cannot be considered sufficient evidence for the superiority of this method over the parenteral therapy which is dealt with rather superficially. Results of treating two similar groups of patients with propeptan and with parenteral therapy should have been submitted. It seems that Urbach does not prepare his own extracts. If this assumption is correct, it might explain in part the inadequate evaluation of parenteral therapy and its results. The stress on conservativism in nasal surgery is very gratifying.

Some inaccuracies should be mentioned. In this reviewer's knowledge, ragweed pollination in Baltimore and Richmond has not been reported before August 7th, contrary to Urbach's table for these regions. On p. 742 it is said that tuberculin treatment should be given intracutaneously. The maximum, however, should never exceed 1 cc. of a 1:10,000 dilution (which dose would be difficult to inject intracutaneously). Miner's asthma is mainly due to silica dust, not to coal dust as stated. In describing the technic of treatment in menstrual migraine the author says: "The blood is centrifuged and preserved in steril ampouls" (p.933). Apparently the serum is meant to be preserved, not the blood.

The collection of 400 illustrations is a valuble adjunct to this work which will be useful particularly for research workers as a source for references.

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PARASITIC DISEASES AND AMERICAN PARTICIPATION IN THE WAR. *Annals of the New York Academy of Sciences, Volume XLIV.*

By Horace W. Stunkard, Lowell T. Coggeshall, Thomas T. Mackie, Robert Matheson, and Norman R. Stoll. New York Academy of Sciences, New York. $1.00. 9¼ x 6⅛; 191–261; 1943 (paper).

This report of a conference held by the New York Academy of Sciences illustrates the serious thought that is now being given to the parasitic diseases in our country. Until our entry into the present world war there was relatively little interest in this subject in the United States. Other countries with extensive tropical possessions have had ample opportunity to become fully conscious of the importance of tropical medicine. For years, many of them have had well-established teaching and research institutions devoting their entire efforts to furthering our knowledge of tropical medicine. Although the United States is by no means free of the so-called tropical diseases we have sadly neglected that phase of medical education. One of the reasons for our neglect of parasitic diseases had been the unfortunate practice of designating them as purely tropical in distribution. It is true that they occur more frequently in the tropics, but nevertheless most of them are fully capable of creating health problems in temperate climates. This became quite apparent when an epidemic of amebiasis occurred in Chicago during the 1933 World Fair. That occasion also illustrated the serious consequences that can result when a medical profession is not sufficiently acquainted with the insidious activities of human parasites. The great number of deaths that occurred is attributed to incorrect diagnosis by the attending physicians. Now with a large proportion of our army and navy personnel distributed around the world in the tropical and subtropical areas, we have at last recognized our shortcomings and are taking steps to eliminate them.

At this particular conference of the Academy held on March 13, 1943, a group of outstanding authorities presented a series of papers on various subjects related to parasitic diseases and our participation in the war. After an interesting introduction by Horace W. Stunkard, the following papers were presented: "Current and postwar problems associated with the human protozoan diseases," by Lowell T. Coggeshall; "Changed viewpoints of helminthic disease: World War I vs. World War II," by Norman R. Stoll; "Arthropods as vectors of human diseases, with special reference to the present war," by Robert Matheson; "Clinical features of parasitic diseases and their consideration in military and naval operations," by Thomas T. Mackie. After each presentation, the paper was discussed by various persons attending the conference. The comments are included in the present publication.

The general conclusion that one can derive from reading the report is threefold: first, many of our service men will acquire parasitic diseases which may result in serious military as well as health problems; second, due to the nature of these diseases, a certain percentage of these men will still be infected with various parasites when they are returned to civilian life;

and third, it is not clear, at present, to what extent these infected individuals and the accidental introduction of insect vectors will enable new and more virulent parasitic diseases to become established in this country; nevertheless, our health agencies are apparently aware of the problems and are striving to prevent such an eventuality.

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ELEMENTS OF MEDICAL MYCOLOGY.

By Jacob Hyams Swartz. With an Introduction by Fred D. Weidman. Grune and Stratton, New York. $4.50. 8½ x 5⅝; 179 + 1 folding chart; 1943.

Out of the rapid increase in the field of medical mycology in recent years has arisen the need for an elementary volume presenting as much as possible of the field within the limitations of simplicity and conciseness. This compact book meets this need competently. Its size could permit the margins being trimmed to 5 x 7 inch size suitable for a pocket manual with soft binding, thus greatly extending its usefulness to field medical forces.

The approach is that of the pathologist, from the causal organism and its characteristics to the symptoms, nature, and treatment of the disease, rather than the clinician's approach. In the first chapter the reader is introduced to fungi and acquainted with the nature, structure, development, reproduction, and relation to disease. The second covers the laboratory procedures, microscopic study, cultural characteristics with the various tests and methods of examination which, with the clinical picture, permit adequate diagnosis of fungous infections. The four chapters which follow deal with the groups of causal fungi, each being considered according to the general scheme of the fungi concerned, their mycologic, clinical manifestations, immunologic reactions, and treatment. In this manner the Blastomycetes, *Microsporum* and *Trichophyton*, are discussed effectively, while in Chapter VI, in the same general manner, though necessarily more briefly, other pathogenic fungi are taken up. A chapter on common contaminants briefly introduces the reader to the air- and dust-borne fungi, against which the dermatologist must be on guard, as contaminants all too frequently encountered in laboratory cultures are too easily assumed to be causal agents.

The two final chapters helpfully discuss reactions to trichophytin and oidiomycin tests and touch upon the effects of the sulfa drugs in fungi, favorable in some cases, doubtful or negative in others, suggesting rightly that further studies will be necessary before we can evaluate adequately the importance of these agents against fungous infections.

The illustrations comprise seventy-eight figures, the many half-tones of clinical signs and symptoms, and of microscopic characteristics being uniformly excellent; the few line cuts rather crude but clear. A chart, 20 x 15 inches, with its tabulation in parallel columns of the organisms, the clinical pictures, and the mycological findings, is a very useful feature. The references are given at the end of each chapter; the serviceable index of seven pages is condensed but adequate; the glossary of seven pages will be helpful to those unfamiliar with the technical terms of mycology.

A few typographical errors, such as Rhyzopus, Cryptograms, are to be noted. The use of fungus as an adjective instead of fungous or fungal is open to criticism, as is the confusion in the use of pleomorphism in the glossary, in the sense of polymorphism, and elsewhere in the somewhat specialized meaning of Sabourand. Since, to save space, the discussion of the next causal fungus frequently begins in the middle or toward the bottom of a page, it would help to make such headings stand out if a distinctive type were used, instead of capitals very similar to other sub-headings.

Compact, informative, well illustrated and succinct, this presentation of the elements of medical mycology should prove of wide value.

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AN INTRODUCTION TO MEDICAL MYCOLOGY. *Second Edition.*

By George M. Lewis and Mary E. Hopper. The Year Book Publishers, Inc., Chicago. $6.50. 7 x 10¼; xviii + 342; 1943.

This second edition needs no introduction or commendation to the many enthusiastic users who found the first edition of 1939 by far the most practical, comprehensive, and helpful volume available in the field.

Those who, by some chance, are unfamiliar with the first edition will find in Part I, in 206 pages, a thorough treatment of the clinical, theoretic, and experimental aspects of the subject covering the classification, structure, and nature of fungi, methods of diagnosis, immunity, and cutaneous sensitization, while the superficial mycoses and the deep mycoses are discussed in detail, the approach being from the clinical to the mycological and laboratory aspects.

Part II, in 128 pages, presents the necessary laboratory methods in most helpful clarity and detail. Here also, in Chapter XXXII, are given the microscopic, mycological, and cultural characteristics of the pathogenic fungi causing the mycoses described clinically in Part I, twenty-five of the most important of these being treated in detail. Other pathogenic fungi, seven species, are described in Chapter XXXIII, while subsequent chapters consider fungi probably pathogenic, fungi questionably pathogenic, and the contaminants commonly encountered. Seventy-seven excellent illustrations effectively present many important clinical and mycologic features. The references at the end of each section or chapter adequately supplement the text, as does the list of general references at the end of the book, while a detailed index of seven pages facilitates and expedites references.

This second edition has obviously been thoroughly revised to include the advances in the field during the four years that have elapsed since the first appearance of the book. There have been added new and significant sub-chapters to include recent work on histoplasmosis, tinea rodosa, rhinosporidiosis, and mycoses of the lungs. Revisions have evaluated recent material in the rapidly advancing field of the trichophytin, sporotrichin, and other tests, while the relation of fungous spores to asthma and hayfever, one of the modern developments in medical mycology, is well, though briefly, covered. Included also are up-to-date directions for the treatment of difficult dermatophytoses and the recent advances in laboratory technique. The volume, already practical and almost indispensable to the dermatologist, has thus been rendered even more valuable. Its appearance is most timely now when, with large numbers of men in army camps and in tropical theaters, the attention of medical men is being increasingly directed to the importance of fungous infections.

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PERSONAL AND COMMUNITY HEALTH. *Seventh Edition.*

By C. E. Turner. C. V. Mosby Company, St. Louis. $3.50. 8½ x 5⅜; 585; 1943.

Health instruction at the university level is now generally recognized as desirable. Students face new health problems and need more extensive knowledge. Moreover, much is expected of them. Many will enter some occupation or profession concerned with health, education, social welfare, or government. Most of them will have responsibility for the health of a family. All should acquire the standard of health knowledge appropriate for educated men and women—one which will enable them to meet their proper health responsibilities in the workplace, in the home, and in the community.

This book is planned for the various college-level groups. It seeks to present the essential, present-day knowledge of personal and community health within available time and space limitations, and with enough anatomy, physiology, and other underlying sciences to clarify and support the health teaching. The fact that it has already gone through six editions is ample evidence of the success with which this volume has met the needs of college and university students. The present edition promises to be as widely used as the earlier ones were. As the author points out, the field covered by the text is broad; the science is advancing rapidly; and the motivation of health knowledge into student health behavior is often difficult.

The subject-matter of this volume is divided logically into two parts: personal health and community health. Under the first heading are discussed: nutrition, digestion, oral hygiene, respiration, circulation, the kidneys, the skin, endocrines, the sense organs, the hygiene of the nervous system, of body activity, and of reproduction, mental hygiene, body mechanics, heredity and health, narcotics and stimulants, and adult hygiene. In the second section, we are given information concerning: the science of disease prevention, communicable diseases, immunity, food control, water supply, waste disposal, ventilation, heating and lighting, public health administration, maternal and child hygiene, school hygiene, and industrial hygiene. The appendix contains material on the control of communicable diseases, on disinfection and disinfectants, an excellent glossary, and a list of prefixes, suffixes and combining forms. The book is quite appropriately illustrated. References are given at the end of each of the chapters. There is a complete index provided.

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CHINA'S HEALTH PROBLEMS.

By Szeming Sze. Chinese Medical Association, Washington, D. C. $1.00. 9 x 6; 60; 1943.

One cannot help noting the very deep interest which exists today in America in problems of aid and relief for China, particularly medical relief. Such interest, however, is more often than not focussed on one particular aspect of the general picture, such as the support of mission hospitals or the training of medical personnel. The author feels that there is danger in such cases of the perspective being lost and undue importance being accorded to some particular aspect. An attempt has been made in this book to put the main problems in their proper perspective. For this reason the detailed examination of any single problem has been avoided. Instead the facts have been stated in as brief and simple a manner as possible, only indicating what are the broad aspects of the problem and what are the policies being followed to solve these problems. The problems are long-term and semi-permanent ones, in the author's opinion, and transcend the immediate vicissitudes of the present war. Many immediate war-time problems, pressing though they may seem, have not been discussed in more than a cursory fashion, because they do not fundamentally affect the solution of the more permanent problems. There are further several allied problems which have not been dealt with in any detail for the similar reason that it is not desired for the time being to complicate the discussion of the main problems with subjects of somewhat lesser importance—namely, nursing, midwifery, dentistry, pharmacy, and the manufacture of medical supplies.

In the present account, the author takes up, in order: the scope of China's health problems, state medicine, non-governmental hospitals and private practitioners, health education, medical education, medical societies, Army medical services, civilian medical relief, assistance from abroad, and medical supplies. The appendix contains much information about Chinese health, medical, educational and relief agencies and services, and a list of 104 drugs important in China. References are given in the form of footnotes. There is no index. Physicians and public health workers will find much cogent material within the covers of this little book.

SYNOPSIS OF TROPICAL MEDICINE.

By Sir Philip Manson Bahr. Williams and Wilkins Company, Baltimore, $2.50. 7⅜ x 4⅜; xii + 224; 1943.

Synopsis of Tropical Medicine is a valuable handbook for anyone interested in this phase of medicine. It has been written as a contribution to the war effort by an outstanding authority. With the great number of allied troops stationed in tropical areas, it is imperative that those responsible for their health have available clear, accurate information on the diseases that are certain to be encountered. Tropical medicine is a tremendous field involving many diseases that are imperfectly known, if not entirely mystifying to most medical men. Due to the extensive literature on the subject, it is particularly helpful to have this concise presentation by a person well qualified to select wisely. Nevertheless, the reader should accept the statements of the author with a certain degree of reservation for the necessity of saving space in a handbook of this kind usually demands dogmatic statements of even controversial questions.

The subject matter is well organized. Each chapter presents a group of diseases that have closely related etiological agents, e.g. protozoal diseases, spirochaetal diseases, etc. The discussions of the major diseases are usually divided into the following headings: Geographical distribution and epidemiology, etiology, pathology, clinical features, diagnosis, treatment, and prophylaxis. By the judicious use of bold type and italics, the skeletal outline of each subject is clearly visible. This feature plus the excellent index, makes it particularly useful as a reference book.

There are only two pages devoted to laboratory methods. This is hardly enough for a field of medicine so dependent upon laboratory examinations for accurate diagnosis. In most instances, the descriptions of the etiological agents are not sufficient for proper identification. These inadequacies are compensated for to a certain extent by five plates and five tables that present further details.

INTENSIVE RURAL HYGIENE WORK IN THE NETHERLANDS EAST INDIES. *A Document for the Eighth Conference of the Institute of Pacific Relations, December, 1942.*

By J. L. Hydrick with an Introduction by J. Snapper. Netherlands Information Bureau, New York. 9¼ x 6⅛; 83; 1942 (paper).

Since the middle of the nineteenth century the Government of the Netherlands had carefully organized the health service of the Netherlands East Indies. The high scientific standing of the physicians and other medical officers who worked in this service is easily demonstrated by their important contributions to the field of tropical medicine and hygiene. Among these may be mentioned: the discovery of the avitaminoses in general, and of avitaminosis B in particular, by Eykman; the isolation and crystallization of pure vitamin B_1, by Jansen and Donath; the investigations in the field of malaria prophylaxis, by Swellengrebel and by Walch; the leptospira work of Schüffner and his pupils; and the use of living plague vaccines by Otten. Gradually the Public Health Service of the Netherlands East Indies spread over many fields, as discussed and described in the present report, and experts of different countries have expressed their appreciation of the results which have been accomplished. In recent years several reorganizations have even more increased the efficiency of the health service —one of these improvements being the complete separation of a curative Medical Service from the Public Health Service, with the result that the officers of the latter division were in a position to organize intensive rural hygiene work in the Archipelago. One of the leading principles of this part of the public health program, as explained in this booklet, was to use methods likely to stimulate the interest of the native population and to obtain their active cooperation. At the same time, the activities of the Public Health Service of the Netherlands East Indies were decentralized: hospitals, dispensaries and campaigns against communicable diseases were transferred to Provinces and Regencies.

All of these measures led to rather remarkable results which are here described by the author. The apparently excellent quality of this rural hygiene work, which evidently was only a minor part of the widespread activities of the governmental Health Service of the Netherlands East Indies, may well serve as a signal token of the superiority of the work of this Service.

SOVIET HEALTH CARE *in Peace and War.*

By Rose Maurer. American Russian Institute for Cultural Relations with the Soviet Union, Inc., New York. 10 cents. 8½ x 5½; 48; 1943 (paper).

The remarkable medical record achieved by the Soviet Union in three years of fierce and unremitting resistance to Nazi invasion has aroused among the people of the United Nations a desire to know more about the Soviet health program. What, in terms of aims and practices, lies back of the present demonstration of ability to restore over two thirds of the wounded to active service, to avoid large-scale epidemics, to rehabilitate invalids, to maintain prophylactic and curative work in the rear as well as in the front lines? This interest in how the

Russians have been meeting their health problems in the quarter century of their existence is particularly keen in the United States where the impact of the war on our medical institutions is beginning to be felt by the anxious citizen. The principle adopted by the Soviets has been to make health a community matter. This brief pamphlet is intended to serve as an introduction to their experience in applying that principle. The author's acquaintance with the various facets of Soviet health care is both a personal and a scholarly one, she having lived and studied in the Soviet Union for several years.

The discussion is divided into two parts: (1) before the Nazi attack, and (2) Soviet medical care in wartime. In the first part, material presented includes: health protection at place of work, district health centers, special care for women and children, rural medical services, medical education and research, drug manufacture, nutrition study, health statistics, and community participation in the health program. In the second part we learn about: military medicine, rehabilitation of the wounded, health problems in reoccupied territory, problems of evacuation, wartime research, and total medical care in total war. The author's presentation is clear, concise and thought-provoking, and deserves careful consideration by all those concerned with public health matters. There is neither bibliography nor index provided.

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THE FOOD RESOURCES OF AFRICA. *African Handbooks: 3.*

By Thomas S. Githens and Carroll E. Wood, Jr. The University of Pennsylvania Press, Philadelphia. $1.50. 8½ x 5½; 105; 1943 (paper).

Africa, an important contributor to the world's agricultural supply, has now more than ever a vital share in the food economy of the world. The Japanese conquest of the Far East has cut off important food supplies, and it is necessary to look for new fields to increase the production in those territories at the command of the United Nations. Africa's proximity to the major battle fronts makes it an area particularly strategic in location from which to supplement the depleted food supply, and the African natives contribute to this task in no small measure. Thus, the meager fat rations of Great Britain have come to depend largely on the amount of groundnuts, palm oil, and palm kernels which West Africa can furnish, and the Middle Eastern armies are supplied with food from East African territories. The fact that, despite Africa's importance, only scant information about its food production is available, makes the situation potentially dangerous. Not only might valuable food sources be ignored, but conversely, Africa's productivity might be overestimated and lead to disastrous local famines if drained too much, as, indeed, occurred in some East African territories early in 1943. For the United States, which contributes such a large share of food to both Allied and conquered nations, it is of special interest to learn and know about those food resources which now or in the near future may be available in other parts of the world.

The present studies by Githens and Wood succeed in giving a very fine general survey of Africa's agricultural resources. The discussion is clear, complete and authentic. The material is interestingly and intelligently written and affords a wealth of information for the average layman. The various geographical divisions of tropical and north Africa are considered in turn. The appendix contains a survey of Africa's food resources, and a list of the food plants of the "dark continent." There is an extensive bibliography, but no index.

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REACTION TO INJURY. *Pathology for Students of Disease Based on the Functional and Morphological Responses of Tissues to Injurious Agents.*

By Wiley D. Forbus. The Williams and Wilkins Company, Baltimore. $9.00. 10 x 6⅞; xix + 797; 1943.

This book is designed as a guide to students of disease. It is built about the specific theme that disease is a matter of the abnormal outcome of a constantly changing relation between the cell and its environment; this abnormal outcome is or may be unfavorable to the individual as a whole. The volume contains the first two parts of a contemplated four-part treatise. Part One is a brief introduction to the study of disease and consists of definitions of disease and the scope of pathology, a history of the development of medicine, a description of the present day concept of disease and a classification of the ways in which the body may respond to injury. It closes with a detailed discussion of the intrinsic, extrinsic, inanimate and animate factors involved in the causation of disease. Part Two deals with the resistive reaction to injury. The nature and significance of inflammation is outlined. Morphological, functional, chemical, and immunological inflammatory reactions of tissues are described and reasons are given for classifying the various types of inflammation as acute, chronic, and granulomatous. The following three sections of this division of the book are devoted to a consideration of specific types of injury and disease. Section one is comprised of a detailed description of the reaction of the body to bacterial injury. The second section deals with the reaction of the tissues to injury by obligate cellular parasites—the acute infectious diseases that follow invasion of the body by viruses and the rickettsiae. The third and final section of the volume describes reactions of the tissues of the body organs to injuries produced by foreign bodies, bacteria, treponemata and the fungi—the chronic granulomatous diseases. The great mass of material incorporated in the chapters of these sections of Part Two is skilfully organized, clearly presented and well illustrated.

◆

PAIN MECHANISMS. *A Physiologic Interpretation of Causalgia and Its Related States.*

By W. K. Livingston. The Macmillan Company, New York. $3.75. 8½ x 5⅝; xiii + 253; 1943.

The author presents his clinical experience with various painful conditions, particularly causalgia and reflex paralysis, post-traumatic pain, chronic low back disabilities, facial neuralgia, phantom limb pain, offering an interpretation of data which includes the anatomy, the physiology and psychology of pain, and treatment methods. In a sense this is a personal monograph containing the author's own experiences and his interpretation, but it also calls heavily on the literature, particularly that attributable to Sheehan, Hinsey, Riddoch, Lewis, Head, Weir Mitchell, and others. He recognizes clearly that pain can be understood only in terms of levels of integration up to the psychic. He attributes to the internuncial neurones a very important part in the physiology of pain, the actual final effect of sensory impulses being determined by the state of the internuncial neuron pool, itself dependent upon a great many other factors, including emotional states.

The book is essentially conservative, but also presents material the upshot of present investigations of the subject.

This reviewer would take issue with only one item in the book, namely, his feeling that malingering is not uncommon in post-traumatic pain syndromes. That "... workmen who consciously, or unconsciously, exaggerate their suffering and the degree of disability in the hope of being given a higher permanent disability award when their claim is closed" do exist no one will deny. It is this reviewer's opinion that very few such patients may be indisputably malingerers. The post-traumatic state is a very difficult one to unravel. Unconscious hysterical manifestations, however, are much commoner than is malingering. I am inclined to feel that the author used the term "malingering" in the sense used by laymen and by many physicians, not psychiatrists. Aside from this item the material on the post-traumatic states is excellently presented.

◆

A HUNDRED YEARS OF MEDICINE.

By C. D. Haagensen and Wyndham E. B. Lloyd. Sheridan House, New York. $3.75. 9¼ x 6; xii + 443; 1943.

The book is divided into four major parts: I. Medicine and health conditions 100 years ago, i.e. at the beginning of the modern era; II. The development of medical science (pathology, bacteriology, diagnostics and therapeutics) during the last 100 years; III. The development of surgery and its subdivisions during this period; IV. The new social aspects of medicine.

The book was originally published in 1936 in London by Wyndham Lloyd, a public health man. It has now been adapted to the American scene, greatly expanded and entirely rewritten by Haagensen, a surgeon and pathologist. It is hard to see why Haagensen did not write a new book altogether as, naturally enough, the emphasis of the book has shifted entirely towards an analysis of progress in surgery. That does not mean that Haagensen has not contributed also some excellent chapters on progress in internal medicine, e.g. on heart diseases or tuberculosis. But that psychiatry also exists, seems to have been forgotten, and endocrinology is only treated in so far as it has a bearing on surgery. These are, of course, serious gaps in a study which pretends to cover the whole field of medicine. But this is an impossible attempt anyway when undertaken in one book of 400 pages by one author. For such a large enterprise there are only very few and small errors in detail. The history of Virchow in 1848 is messed up as usual. The book tries to illustrate the almost miraculous progress of the last 100 years, less in insisting on the great principles and trends than by adding the different partial discoveries.

Within these limits it is an excellent, fascinating piece of work and highly recommendable not only for laymen and medical students for whom it is intended, but for readers with higher pretensions. The illustrations are particularly good.

◆

STARVATION IN EUROPE.

By Geoffrey H. Bourne. Allen and Unwin, London. 5s. 7⅜ x 4⅞; 144; 1943.

The author shows that Germany has wanted two things from the occupied countries—food and labor. Bearing these two facts in mind, her policies toward them, though seemingly diverse, can be seen to fall into a well-defined pattern. Any food that can be taken from an occupied country is taken. If the food production in any country results in a surplus, then the population is left enough to eke out a just bearable existence. If the country is not self-sufficient, then its inhabitants starve. The only people who have been able to get reasonable rations in the occupied countries are the industrial workers and even their rations are inadequate. Greece has practically no industry and is unable to produce more than a small amount of her food requirements; therefore, she starves. The author believes that Germany's policy in keeping the peoples of Europe on a semi-starvation level serves two purposes: it forces workers to labor for Germany (because industrial workers get bigger rations), and it minimizes the dangers of revolt (because, in general, half-starved people have less spirit and less strength to fight).

This book attempts, by explaining all of the technical terms used, to interpret the present nutritional state of Europe to the layman, but at the same time it sets out to provide a scientific and unemotional analysis of the situation. Based on this analysis, some suggestions are made in the last chapter concerning the relief of Europe after the war and also concerning the future organization of world nutrition. The picture presented is not a pretty or pleasant one to contemplate, but it is based on actual facts and as such it is quite important and deserves a wide reading, especially by those who complain of food rationing in this country. The excellent photographic illustrations add immeasureably to the poignancy and effectiveness of the subject-matter. The book is completely indexed.

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HANDBOOK OF TROPICAL MEDICINE.

By Alfred C. Reed and J. C. Geiger. Stanford University Press, Stanford. \$1.50. $6\frac{3}{4}$ x $4\frac{5}{8}$; ix + 188; 1943.

It must be exceedingly difficult to write a brief readable handbook. However, in the opinion of the reviewer, Reed and Geiger have succeeded in this task. The statements in most publications of this type are so short that the text material loses all continuity of thought and ceases to hold the reader's interest. This does not mean that the present authors have entered into wordy discussions. They have fulfilled the aim expressed in the preface, to reduce the subject matter "to practical clinical terms, leaving exhaustive and systematic discussions to other works." The book should be helpful to any physician who is interested in obtaining a workable knowledge of tropical medicine.

The authors discuss all of the important tropical diseases in a very adequate manner, but many of the less important diseases are not considered. The clinical and epidemiological aspects of the subjects are stressed throughout the book. Very little attention is given to the description and identification of the etiological agents. Many of the tropical diseases cannot be diagnosed purely on clinical evidence. Therefore, this omission may be serious to those readers who are not thoroughly acquainted with this phase of the subject, or who do not have the information readily available. A few plates illustrating at least the human parasites would have done much to alleviate this objection and would have added much to the attractiveness of the book. A complete index is included in addition to a table of contents.

* * *

A TEXT-BOOK OF THE DISEASES OF THE SMALL DOMESTIC ANIMALS. *Fourth Edition, Thoroughly Revised.*

By Oscar Victor Brumley. Lea and Febiger, Philadelphia. \$5.00. $9\frac{1}{8}$ x $5\frac{5}{8}$; 422; 1943.

The fourth edition of this excellent text has been revised to include the newer knowledge in the different fields without changing the general arrangement of material. Special attention is given to parasites and parasitic conditions and to other fields where recent advances have been most rapid. As in former editions, the metric system is still used, but a table of equivalents in weights and measures has been included for the determination of dosage in the other system if desired. This is also the first edition of this text to contain illustrations. Although somewhat limited in number they form a valuable addition to the volume. With the passing of war conditions more of these could profitably be added.

Throughout, the author has held to his original purpose of providing a substantial working text for students and a handy reference for the practitioner. The style is clear and concise. With the orderly arrangement of the material and the useful index the reader will waste little time in finding the source of any diseased condition and in putting it under treatment. It should be emphasized, however, that the layman will not find this volume a substitute for the veterinary, except, perhaps, in some special fields.

* * *

AUTHORITY IN MEDICINE: OLD AND NEW. *The Linacre Lecture 1943.*

By Major Greenwood. The Macmillan Company, New York; Cambridge: at the University Press. 40 cents. $7\frac{1}{4}$ x $4\frac{3}{4}$; 32; 1943 (paper).

Greenwood's Linacre Lecture deals mainly with Galen and some less known aspects of his work: his epidemiology, his general hygiene, and his medical psychology. Galen's merits seem to justify Linacre's devotion to his authority. Greenwood reminds his contemporaries, who know so well how to scold Galenic authoritarianism, that there also exist among us some "authorities" worshipped beyond the limits of the purely reasonable: the authority of the experiment and the authority of intention. Greenwood pleads against these authorities for the statistical approach and for pure science. He ends with a very warm appraisal of the late Walter Fletcher. This little lecture confirms Greenwood's reputation as being one of the wittiest, most thoughtful and learned lecturers of our time.

* * *

REHABILITATION OF THE WAR INJURED. *A Symposium.*

Edited by William Brown Doherty and Dagobert D. Runes. Philosophical Library, New York. \$10.00. 9 x $6\frac{1}{4}$; 684; 1943.

The enormous armies made necessary by modern wars, and the nature of the fighting itself, create a formidable post-war problem respecting care and rehabilitation of the wounded. The present volume is a symposium embodying the methods of treatment learned during and after the First World War and in the present conflict.

It comprises 53 separate articles, covering Neurology and psychiatry (8 titles), Reconstructive and plastic surgery (16), Orthopedics (5), Physiotherapy (7), Occupational therapy and vocational guidance (14), Legal aspects of rehabilitation (2), and Miscellaneous (1). All but 10 of these papers previously were published elsewhere. Of the 56 contributors, 31 are American, 24 British, and 1 Russian. Most of the articles are illustrated. There is no index.

* * *

Woman Healers in Medieval Life and Literature.
By Muriel Joy Hughes. King's Crown Press, New York. $2.00. 9 x 6; xii + 180; 1943 (paper).

Miss Hughes deals with the women healers, lay or professional, from the 11th to the 15th centuries. She has gathered most of her material from literary sources. Fundamentally she has added very little to the material already collected by the two classic authors on women in medicine: M. Lipinska and K. Campbell Hurd-Mead. And Miss Hughes has done nothing but collect material. She either never had a point of view concerning her subject or she forgot it before starting to write. This is quite surprising as the Middle Ages actually offer quite new problems in medical history in so far as women are concerned; problems resulting from the changed attitude towards women in Christianity, resulting from such new formations as monasteries and universities.

BIOCHEMISTRY

Physical Biochemistry.
By Henry B. Bull. John Wiley and Sons, New York: Chapman and Hall, London. $3.75. $8\frac{5}{8}$ x $5\frac{1}{2}$; iv + 347; 1943.

The problem of how to present physical chemistry to biologists has always been a perplexing one, and has been successfully solved in relatively few courses. Biological research is drawing more and more on the principles and methods of physical chemistry, but few students of biology have either the time or the background necessary to pursue a really complete and rigorous course of study in this subject. It therefore becomes necessary to provide condensed and simplified courses for them. Unfortunately, physical chemistry is not a subject which lends itself readily to simplification. The wholesale elimination of detailed mathematical derivations often leads to a lack of understanding, or misunderstanding of the significance and applicability of the resulting equations, and efforts to put principles into simplified, mechanical terms are only too often inaccurate and misleading.

There is probably no single compromise between simplicity and complexity which will be universally acceptable, but this volume makes a real contribution to the solution of this problem. The book is an outgrowth of a series of lectures given by the author to graduate students in various fields of biology and biological chemistry, and places particular emphasis on the application of various physical-chemical procedures to biological problems. The extremely condensed nature of some of the sections is probably the book's greatest weakness, and it may be severely criticized by some chemists because many theoretical discussions and derivations are either omitted or greatly abbreviated. This is particularly noticeable in the section dealing with thermodynamics. There can be no question but that an understanding of such derivations adds materially to the subject, and the justification of their omission must rest on the fact that many of those for whom this book is intended would not really understand them if they were included.

As the author points out, this book does not present a complete course in physical chemistry, and numerous literature references are provided to help fill in the gaps. These include a wide selection of both classical and current papers. In both the selection of references and the arrangement of the text, considerable emphasis is placed upon techniques and methods. Numerous discussions of the practical applications and limitations of various methods are included, and these should have a very real value to many biologists who must face the problem of determining the physical and chemical characteristics of various systems with only a limited background in the physical sciences.

The book is primarily intended for advanced undergraduate or graduate students in biology with a fair knowledge of chemistry, physics and mathematics. However, many older biologists not directly involved in biochemical work will undoubtedly find it to be a valuable and convenient source of information. It is provided with an adequate subject index.

* * *

Frontiers in Cytochemistry: *The Physical and Chemical Organization of the Cytoplasm. Biological Symposia, Volume X.*
Edited by Normand L. Hoerr. The Jaques Cattell Press, Lancaster. $3.50. $9\frac{5}{8}$ x $6\frac{5}{8}$; 334; 1943.

The tenth volume in this series of Biological Symposia consists of papers presented in honor of R. R. Bensley of Chicago on his seventy-fifth birthday. It deals with the physical and chemical organization of protoplasm, and shows the scope of recent advances in this field.

The contributions of Bensley and his group are summarized in a foreword by Hoerr and in reviews by Bensley and by Lazarow. Twelve other papers describe individual contributions of members of the Bensley school and other workers in cytochemistry.

The majority of these papers present various techniques, including methods of isolating and purifying different cell components (e.g., chromatin threads, mitochondria, submicroscopic particulates, "structural proteins") and methods and tools for manipulating these components and analyzing their physical and chemical structure (e.g., by chemical analysis, micro-injection, micro-incineration, and the use of the ultracentrifuge and the ultra-violet and electron microscopes).

In many cases these techniques have led to valuable results in the analysis of protoplasmic elements, but in too many cases the techniques seem to have been applied uncritically without specific aims or results.

While the proper application of technique has resulted in descriptive data of considerable extent and importance, the question of the rôle of different cell constituents in cellular physiology remains largely speculative; and the control and coordination of different functions within the cellular architecture constitute a still more difficult problem, as Barron points out in a paper on cellular respiration.

The approach to these problems of function and coordination is indicated by work where cytochemical techniques have been used as tools for the analysis of changes in experimentally treated or pathological tissues. The few papers describing work of this type represent perhaps the most notable advance in the field. The importance of the preliminary advances in technique and descriptive cytochemistry lies in the basis which these provide for experimental work on the relation of the vital processes to protoplasmic structure. The collection of papers presented here, while mainly concerned with the explorer's equipment, brings us to the very edge of this unexplored territory which is of such fundamental interest to the biologist.

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Chemistry and Methods of Enzymes.

By James B. Sumner and G. Fred Somers. Academic Press, New York. $5.00. 9 x 6; xi + 365; 1943.

This book may be briefly described as presenting in an orderly manner a great number of facts about many different enzymes. It is designed to occupy an intermediate position in its field, being more comprehensive and critical than the usual textbook on the subject and yet not claiming the completeness of a strictly reference work.

The first and last chapters, "General properties of enzymes" and "Carbohydrate metabolism" provide a broader treatment of the subject than the remainder of the book. The first of these presents a very condensed "textbook" survey of enzymes, but is hardly extensive enough to make the book meet the needs of those who have had no previous knowledge of enzyme chemistry. The chapter on carbohydrate metabolism provides a general survey of the subject centered largely around discussions of the Szent-Györgyi and Krebs cycles. An attempt is made to evaluate both sides of the controversies which have developed around these postulated mechanisms, but lack of space makes it necessary to limit some pertinent arguments to references to selected papers dealing with the subject. The chapter is therefore not completely self-contained, but it does provide the outline and the references necessary for a comprehensive study of carbohydrate metabolism.

The other 16 chapters of the book are devoted primarily to brief discussions of the present state of knowledge regarding over 150 of the best known animal and plant enzymes. Short sections are included dealing with the history, occurrence, action, specificity, activity measurement, activation and inactivation, preparation, and properties of each of the enzymes. These sections vary greatly in length depending upon the amount of pertinent information available on the topic under consideration.

The authors state in their preface that this book is an ". . . attempt to give the research worker and advanced student a general survey of enzyme chemistry without presenting too much detail on any one subject," and they have done an admirable job. It provides easily accessible, pertinent and concise information regarding most of the enzymes which have been studied in any detail, and the numerous selected references accompanying each chapter enable one to readily fill in details omitted from the text itself. The book is also provided with adequate author and subject indexes.

◆

Biochemistry of the Fatty Acids *and Their Compounds, the Lipids.*

By W. R. Bloor. Reinhold Publishing Corporation, New York. $6.00. 9 x 6; xi + 387; 1943.

A real need has existed for some time for a volume summarizing our knowledge of fat biochemistry. Of the three great groups of organic food substances, the lipids have received the least attention from biochemists, but recent studies, including those on the nature of the cell surface, have shown the fatty acids and related compounds to be second only to the proteins in their importance in living structures. It is therefore important that the widely scattered and often inconclusive work on these compounds should be compiled and edited to provide a convenient source of information for those having occasional use for such information as well as to provide a basis for further research in the field.

The present volume attempts to bring together this scattered information, and on the whole, it has achieved gratifying results. In this field there are many loose ends in the form of early experiments which have not been adequately followed up with the use of more recently developed techniques. This condition greatly increases the difficulties involved in writing a review, but this older work appears to have been carefully covered in the present volume.

As the title indicates, the primary emphasis of the book is on the biochemistry of these compounds rather than on the structural organic chemistry. In some cases structural formulae are considered somewhat uncritically and without adequate consideration of recent work disproving or questioning configurations which had previously been accepted. The biochemical aspects of the subject are more thoroughly covered, and five of the six chapters are primarily devoted to a discussion of the normal and pathological distribution and metabolism of various lipids.

A book of this scope could not hope to include a complete bibliography, but an extensive list of selected references accompanies each chapter. The material is made readily available for reference use by a very complete table of contents and an adequate, but not exhaustive, subject index.

* * *

The Biochemistry of Malignant Tumors.
By Kurt Stern and Robert Willheim. The Chemical Publishing Company, Brooklyn. $12.00. $8\frac{1}{2}$ x $5\frac{1}{2}$; xiv + 951; 1943.

This is a courageous attempt to cover the biochemical aspects of cancer as they have been disclosed in some 4500 references, published, mostly, during the 25 years prior to 1942. The scope of the work is indicated by the ten chapter headings: Inorganic chemistry, Organic chemistry, Physical chemistry, Enzymes, Nutrition and vitamins, Metabolism, Endocrine glands and their hormones, Immunology, Biochemical aspects of tumor origin and tumor growth, Chemical and biological tumor diagnostics. This grouping of the vast material is admittedly arbitrary, but it serves the announced general purpose.

One may well imagine the difficult problem posed by the profusion of material so varied in quality and, often, so contradictory in nature. It is inevitable that portions of the work should assume the character of an annotated bibliography. In spite of the difficulties, there is achieved a semblance of orderly arrangement and a measure of critical evaluation.

In summary, the book is a systematized chronicle of a quarter-century of persistent research on the chemistry of a major medical problem. It is obviously not a textbook, and was not intended to be one. To the investigator, the volume may well be of value for orientation, and for tracing the development of the various notions concerning biochemical processes in cancer.

BIOMETRY

Treatment of Experimental Data.
By Archie G. Worthing and Joseph Geffner. John Wiley and Sons, New York: Chapman and Hall, London. $4.50. 9 x $5\frac{3}{4}$; ix + 342; 1943.

The authors of this textbook wrote with the problems of the physicist, chemist and engineer in mind, but the methods presented are equally applicable to problems in other sciences. A number of the illustrative problems are, in fact, taken from biological fields. A listing of the topics covered will indicate the scope: representation of data by tables, by graphs, and by equations; tabular and graphical differentiation and integration; Fourier series; the normal frequency distribution; means and precision indices; the adjustment of conditional observations; least square method; correlation; analysis of nonharmonic periodic functions. An appendix discusses briefly the method of determinants.

The preface states that the book is in part a consequence of a long series of irritations, through encountering badly presented data, and treatments carried through without regard for the assumptions and limitations of the method. It is natural to expect, therefore, that the material will be very critically presented. However, this is not always the case, and the chapters are rather unevenly written with regard to statement of assumptions and interpretation of results. Two or three illustrations will serve to indicate some of these limitations.

The statement of graphical principles fails to emphasize that the nature of the observations essentially governs the type of graph which is appropriate. Thus, the first illustration presents census counts of the United States from 1790 to 1940, in two different ways, both of which are apparently considered correct. In graph A, the x scale (which is not titled), is laid off in bands called 1790, 1800, etc., with the band representing 1790 equal to that between 1790 and 1800. Furthermore, the population is plotted as a bar over the entire year 1790, which implies that the census pertains to a year instead of an instant of time. In graph B, however, for the same material, the x axis is treated as a time scale. In the second illustration, rainfall in inches is plotted against months of the year, and both the months and rainfall figures are plotted as if the months were equal in length. Thus the graphs are subject to the same criticism that the authors level at others. There is little to guide the student as to the use or interpretation of semilog, log-log, or other special papers, although they are introduced. The classification of graphs as qualitative and quantitative is made, not on the basis of the type of material, but on the use to which the graphs are to be put. Thus, the population graph described above is called qualitative because time has been presented as if it were unscaled, although we are dealing with a scaled variable.

In the analytical portion of the book, much of the presentation is similarly disappointing. This is illustrated in the discussion of the correlation coefficient, r. Two interpretations are given for r, one as a measure of the dependency of Y on X, and the other as a measure of common causes. Referring to the latter interpretation, the authors state (p. 281)—"On this basis, it would seem that a correlation of 62% for mathematics-physics grades, would indicate that about 62% of the characteristics or activities required for the two subjects are common characteristics." No justification is given for this very dubious interpretation. They continue,—"Incidentally one would find it very difficult to so interpret a correlation coefficient of 0.95 relating the annual number of marriages in the Church of England and the standard mortality rate for the years 1866 to 1911." In the succeeding paragraph it is recalled "that r is calculated on the assumptions that the values of Y and X are distributed normally and that, on the average, Y is directly (or inversely) proportional to X." The first assumption makes the calculation of the correlation coefficient just quoted, let alone its interpretation, ridiculous. The second assumption is not true. It should be that X and Y are linearly related, not proportional. In the summary of the correlation coefficient there is no mention of the normal assumption other than the statement (p. 290): "Correlation coefficients may be shown to be connected with frequency distributions."

These illustrations will serve to warn the student that the text must be studied with a good deal of critical judgment and supplemented with other presentations of the same subject. Nevertheless, for the real student it can be a useful book, to introduce him to a wide range of subject matter which he will be stimulated to pursue further.

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The American-Born in Canada. *A Statistical Interpretation.*

By R. H. Coats and M. C. MacLean. Yale University Press, New Haven; The Ryerson Press, Toronto. $3.75. 9½ x 6½; xviii + 176; 1943.

This volume is the third in the series dealing with various aspects of Canadian-American migration, the other two being *The Mingling of the Canadian and American Peoples*, by Hansen and Brebner, and *The Canadian Born in the United States*, by Truesdell.

Part I discusses the distribution of the American-born and its significance, and Part II contains 77 basic statistical tables and their analyses. These deal with such subjects as period of immigration, geographical spread, age, sex, family composition, race, mother tongue, citizenship, school attendance, religion, and occupation. Any volume which presents such a wealth of material cannot be adequately reviewed within the limited space available. Only a few of the outstanding facts will be mentioned.

The number of American-born in Canada numbered 344,574 in 1931 as compared with 1,286,389 Canadian-born in the United States. The American-born in Canada were 0.3 per cent of the United States Population and 3.3 per cent of the Canadian population. The Canadian-born in this country were 12.4 per cent of the Canadian population and 1.1 per cent of the population of this country. Thus, the Canadian loss in natives coming to this country was greater in absolute and relative size than the corresponding American loss to Canada, and yet their relative gain in migrants from this country was greater than ours from Canada.

The assimilability of the American-born in Canada is studied in several ways. As to their geographical spread, in the 222 counties or other census districts in Canada, there is not one that does not contain persons born in the United States. Not only that, but the American-born are spread with remarkable evenness through these districts. Similarly in their occupation distribution, there is a very even distribution among the 71 occupational classes, and the common impression that the American-born are mainly agriculturists is not warranted. Also in their tendency to intermarry with Canadians, the American-born show no isolationist characteristics. The authors conclude that the "American-born are accelerating race infusion and the unification of citizenship in Canada."

The discussion about the statistical tables is vividly written, and even the nonstatistical reader will find the text full of interesting ideas. For the student of population problems, this is an important drawing together of the basic facts dealing with the interrelationships of the peoples of the two countries.

◆

Causes of Rejection and Incidence of Defects. *Local Board Examinations of Selective Service Registrants in Peacetime. An analysis of Reports of Physical Examination from 21 Selected States. Medical Statistics Bulletin No. 2.*

Prepared by Thomas I. Edwards and Leonard G. Rowntree. National Headquarters Selective Service System, Washington, D.C. 10⅜ x 8; 41; 1943 (paper).

During the period from November, 1940 through September, 1941, approximately 3,000,000 registrants were examined at local boards. A typical group of 1000 registrants examined at these local boards could be classified as follows: 438, or 43.8 per cent, would be rejected at local board examinations; 90, or 16.0 per cent of the remaining 562, would be rejected at induction stations. Thus, of the original 1000 registrants examined, 528 would be rejected, representing a combined rejection rate of 52.8 per cent. Rejection rates increased steadily with age, with 41.6 per cent of the 22-year-old group being rejected, while 80.3 per cent of the 36-year-old registrants could not be accepted. Tooth defects were the leading cause of rejection, accounting for 16.5 per cent of all rejections at local boards and induction stations. Other causes of rejection, in decreasing order of their importance, were: eye defects, mental and nervous conditions, cardiovascular irregularities, musculo-skeletal defects, hernia, venereal diseases, ear, nose and throat troubles, tuberculosis and other lung diseases, educational deficiency, defects of the feet, and underweight.

Negro registrants had higher rejection rates than whites at local boards and induction stations, 59.4 per 100 examined as compared with 51.9 per 100. Most of the difference in rejection rates was due to the higher rates of rejection for syphilis and for educational deficiency among Negroes, as Negroes had lower rates of incidence than whites for most other defects. The average white registrant was 26 years old, 68.5 inches tall, and weighed 152.2 pounds. The average Negro registrant was also 26 years old, was 68.1 inches tall, and weighed 150.8 pounds.

This report discusses, in order: selection of registrants for examination, rejection rates, rejection rates in relation to age, causes of rejection, incidence of all recorded defects, and height, weight, chest and umbilical girth. The technical appendix gives information on: physical examination forms, sampling procedure, coding, punch cards, age distribution, and other statistical and tabular material. The pamphlet contains a list of references, but is not indexed.

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MANOMETRIC METHODS *as Applied to the Measurement of Cell Respiration and Other Processes. Second Edition.*

By Malcolm Dixon. Foreword by Sir F. G. Hopkins. Cambridge: at the University Press: The Macmillan Company, New York. $1.75. $7\frac{3}{8}$ x 5; xiv + 155; 1943.

The first edition of this laboratory handbook appeared in 1934. Previously, there had been no general account of the theory and application of the methods described. Since then there have been many advances in these procedures, not so much in development of new principles as in improvements in techniques and extension in scope of the problems to which they have been applied. These advances have resulted in a complete revision of the previous edition and the addition of considerable new material.

Although the book has been referred to as a laboratory handbook, it is really more than that for the principles upon which the various techniques are based are considered in detail. Part I is composed of three chapters which describe respectively three different types of manometer, the constant-pressure type, the constant-volume type, and the differential type. Part II is devoted to six chapters on methods of measuring respiration, including a new chapter on micro-methods. A concluding chapter gives a summary of the advantages and limitations of the various methods, and a list of additional applications of manometric methods. There are three appendices, containing useful material for the laboratory man, especially the one giving protocols of actual experiments, in which the results given by the various methods and the calculations and method of recording are presented in detail.

It is of great value to have this clear presentation of such extensively used methods brought up to date.

* * *

DEMOGRAPHIC AND BODILY CHANGES IN DESCENDANTS OF MEXICAN IMMIGRANTS *with Comparable Data on Parents and Children in Mexico.*

By Marcus S. Goldstein. Institute of Latin-American Studies, The University of Texas, Austin. Free. $10 \times 6\frac{7}{8}$: 103; 1943 (paper).

The purpose of this study is to assess the biological effects of the Texas environment on United States-born and American-reared children of Mexican immigrants. The material consists of observations on the members of 305 families, 176 in Texas and 129 in Mexico, comprising some 2000 persons. Observations were taken on 19 anthropometric measurements and a number of other characteristics, such as age of menarche, extent of dental caries, and so on.

The report is considered preliminary in character, but the author feels that the evidence points definitely to certain differentials between children of immigrants and those of persons remaining in Mexico, notably the larger size of the former group.

A very unusual and valuable feature of this report is that the individual anthropometric measurements are included in the appendix, together with the age, sex, date of immigration, and relationship to head of family, of each person. This presents a wealth of source material and offers to other investigators the opportunity for analysis from many points of view.

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THE BULLETIN OF MATHEMATICAL BIOPHYSICS. *Volume 6, Number 2, June, 1943.*

Edited by N. Rashevsky. University of Chicago Press, Chicago.

This number contains the following papers: A note on the mathematical biophysics of ameboid movements, by Ralph Buchsbaum, N. Rashevsky, and Henry E. Stanton; On a possible mechanism for biological periodicity, by Manuel F. Morales; On the theory of cell-division from the point of view of the principle of maximum energy exchange, by Henry E. Stanton; A note on neural nets, by H. D. Landahl; Equivalence of the theories of nervous excitation of Hill, Monnier, and Rashevsky, by Alston S Householder.

PSYCHOLOGY AND BEHAVIOR

CONSCIENCE AND SOCIETY. *A Study of the Psychological Prerequisites of Law and Order.*
By Ranyard West. Methuen and Company, Ltd., London. 15s net. 8½ x 5½; 260; 1942.

In this very stimulating and provocative book, the author attempts a synthesis of the teachings of philosophy, psychology (and psychoanalysis), and political science, dealing with the basic facts of the organization of society through law.

The book is divided into three parts: Part I discusses "human nature" as it appeared to the three philosophers, Hobbes, Locke, and Rousseau. For Hobbes, law was a necessity to keep down the destructive impulses in man, and was achieved by a cold-blooded renunciation of individual rights by enough far-seeing men to keep the others in check. Control of the aggressive impulses in members of the community must rest in a central power, strong enough to fulfill its vital functions, for "covenants without the sword are but words, and of no strength to serve man at all."

Where Hobbes saw man as essentially selfish, Locke saw a cooperativeness and friendliness, essentialy a social instinct. Therefore, where Hobbes saw anarchy, unless a strong self-government were in the saddle, Locke envisioned a peaceable community, which could improve its status by allocating carefully limited powers to a central government.

Rousseau, the French idealist, from the background of an unhappy, timorous, neurotic character saw in government the means to achieve that idealism in society which he actually felt denied him at every turn. This government Rousseau would develop through the voluntary surrender of the individual to the state, so creating a superstate devoted to the welfare of its constituent elements.

The philosophical concepts of Hobbes, Locke, and Rousseau have had their counterparts in the field of political science. Hobbes' has given rise to various nationalisms, typified by the Hegelian concepts popular in German thinking.

Hobhouse, on the contrary, opposing Hegel's teachings, contended the basic fact of political science must rest on the "unity of human nature and the common interest of mankind," and this fact actually must take precedence "above all causes of quarrel" (suggesting Locke and Rousseau). The way to value mankind was to value each individual as such. This antithesis of individual versus state remains today the basis of the varying concepts of government.

International law was first discussed by Grotius, who recognized certain natural God-given laws, which furnish the moral standard for the conduct of international affairs. By contrast, Machiavelli favored the all-powerful prince obligatorily pursuing his desires with any and all means, the end sufficiently justifying them. The concept of sovereignty of the individual state, by which each state is left the sole judge of its own actions, has offered the greatest difficulty in international relations. With such a conception of things, international law must remain only a matter of "pious aspiration," particularly since "both governments and peoples too readily become tainted with the doctrine, as demoralizing for groups as it is for individuals, that in certain 'higher' interests promises can be abandoned, and contracts broken." It is abundantly clear that laws actually function only when and because they have behind them the force of external compulsion.

Modern views of the law suggest: (1) Its function is to maintain the state; or (2) to enrich the community; (3) It exists as that minimum interference to protect the interests of the individual; (4) It consists solely of duties; and (5) It regulates both duties and rights.

Turning to psychoanalysis for a further view of the nature and dynamics of man, the author gives a good account of Freud's discoveries and of his inferences. The latter were colored by his own make-up and of course have been challenged by others with different viewpoints. The author, a psychoanalyst, accepts a middle-of-the-road argument which sees man's struggle in life as an eternal compromise between his aggressive (even destructive) individualistic impulses and his social needs. In certain key people the presence of strong aggressive-destructive impulses of a pathological type may cause damage to the community dependent on them. He cannot agree with Freud in primacy of the destructive impulses (cf. Hobbes).

> In the ordinary individual we find the cardinal characteristics of aggressive violence to be (1) that it is a well-nigh universal potentiality, (2) that it is spasmodically excited, often by means unaccountable to the patient himself, (3) that it is generally unacceptable to (and tends to be repudiated or forgotten by) the social self of the individual, (4) that it requires at bottom external force for its control.

The same facts emerge from the observations of child behavior in nursery schools.

The upshot of all this is that society has learned to control its individual members, but by trial and error and by preserving the basic fallacy that laws are meant for others than the self.

In Part II the author develops a psychological theory of law. Law must be based on (1) "the similarity of human nature which underlies the diversity of men's conduct; (2) the potential and actual diversity of each 'normal' man; (3) the established misconceptions of the minds of men upon which prejudice is built; (4) the vagaries of the 'aggressive' self, and our methods for its repudiation."

The established misconceptions rest upon childhood fantasies and upon their extension through identification into the adult scene. The result of this is that "no man can form an objective and unbiased judgment of a situation in which he is emotionally involved; that no man can safely be admitted a judge of his own cause."

Repression of the aggressive instincts comes about from the normal ascendency of the social instinct, because it was impossible to venture an affront to the demands of the latter. The prime objective of law is the control of human aggressiveness, but law should proceed against the aggressiveness in man rather than against the aggressive man. Law should be grounded on the "fact of the potential criminal in every man." Law may then be defined as "rules for the guidance of conduct imposed upon a society by its sovereign power, which as such is capable of their general enforcement."

International law as at present organized is only a compilation of "pious aspirations," with no status as law, because of the absence of external force for their enforcement, this in turn due to the vicious doctrine of reservation of certain sovereign rights to the states. International "law" at present rests on contractual promises, which cannot be judged or fulfillment demanded by a third uninterested party. For the development of international law, it must be recognized that law precedes the community; the community does not precede and give birth to law.

The author defends the use of analogy in applying the same rules of the development of law as between individuals to the development of law as between larger units, sovereign states. Never will there be a true international community with law until the several states renounce their inalienable rights to self-judgment and action thereon.

In Part III the author discusses the emotion of loyalty, pointing out its practical limitation at present to units no larger than the state. Loyalty is susceptible to leadership and discipline. The job facing us is not to eradicate loyalties to states, but to achieve their transference to a larger unit, and this can be done only by positive methods.

World order will be achieved only when we have learned to live harmoniously with other units *different from ourselves*. The method is by law which transcends all groups, resting on force for its final validity, and appealing to the loyalties of "most men at most times, and a majority of men at all times." This can be achieved by voluntary abnegation of authority by the several states, by imposition through military victory, or by revolution. The guiding rules of world law are two: (1) No unit shall be free to judge its own cause and attempt to enforce its judgment; (2) The many problems of the world shall be judged in imparital courts by the rules of equity.

This is a most important book for the psychiatrist, political scientist, and philosopher. Every page bristles with challenges. It is a book which deals with a subject of personal importance to every inhabitant of this globe. How to be ourselves and live acceptably with others—this biggest problem of each individual, each state, finds here a blueprint for its resolution.

BEHIND THE UNIVERSE. *A Doctor's Religion.*
By Louis Berman. Harper and Brothers, New York.
$2.75. 8 x 5½; 303; 1943.

The nineteenth century philosopher LeConte discriminated between man and the subhuman animals on the ground that man alone in the animal kingdom contemplates the future, and on this premise decided that while the evolution of animals was causal, that of man was partly causal and partly teleological. Whatever we may think of the possibility of a teleological factor of evolution there can be no doubt as to the postulate—man does contemplate his future.

The past is known from historical evidence, the present can be directly experienced, but the future remains hidden by an impenetrable veil. Some future events, such as eclipses and the return of comets, can be accurately forecast from past data, but of those future events which are of the greatest importance for the average man, such as the state of his physical health or that of his bank account, or the date on which the nations will lay down their arms, he knows no more than did the man of Neanderthal.

And this is true not only of the unknown in time but also of the unknown in space. Beyond the horizon that bounds human consciousness lies

"that misty ocean
whose rim no foot hath trod,"

which has never yet been sounded by the plumb line of human intelligence. Yet speculation concerning it is inevitable, because human behavior is so complex that it cannot be determined exclusively by what can be proved mathematically—speculation must play a large part. It is a normal function of consciousness to speculate about that which cannot as yet be known with exactitude.

The work now under discussion is frankly speculative. A successful and prominent physician attempts to tell in straightforward language what he believes to lie beyond the universe which reveals itself through our senses.

Perhaps the most difficult problem that has ever confronted psychology is the origin of the human soul. If we believe that it was somehow inserted extraneously during the course of evolution we must postulate a discontinuity in nature—and since no similar case of discontinuity in nature is known this postulate is offensive to our intelligence. On the other hand, if we believe that it, like our bodies, is the outcome of a process of evolution we must attribute conscious cerebration to the Zoöthamnium, which is nearly as difficult to accept. The author accepts it, however, because it is the less objectionable of the two alternatives.

The metazoa have evolved from the protozoa by a process of cell division—the product cells remaining in contact and becoming specialized. Similarly, according to the author, there has been a parallel evolution of mind, a sort of mental mitosis by which certain mental activities have been concentrated in certain product minds. By studying the activities of the social Hymenoptera and the caste system of the termites he concludes that colonies of these organisms are actuated by a "spirit of the hive," and that the swarm rather than the individual must be considered the psychological unit. An intermediate stage is exhibited by the colonial coelenterate *Physalia arethusa*, which acts as a consolidated individual when confronted by danger, but in which each zoöid reasserts its individuality when danger is past.

The human mind has divided countless times in the course of its existence. Mental life is just as continuous as physical life, and the mental life of an individual is but a single cell in life of the all-inclusive world mind—the mind of God. To LaPlace, God was a hypothesis of which he felt no need, but those who do feel the necessity need not hesitate to mention Him even in a scientific treatise. If those who occupy positions of authority and responsibility realized the implication of such a relationship it might have a salubrious effect on their morality.

The actual division of one mind into two is well exhibited by that type of psychosis known as schizophrenia, generally considered to be an abnormal state. Certainly it is a highly undesirable state, especially if it endures permanently, but strictly speaking it should not be considered abnormal since we are all potentially schizophrenic and come from an essentially schizophrenic ancestry. The reason that we are not conscious of this is the result of another psychosis, amnesia, which is an obliteration of memory and therefore of personality. The schizophrenic, in whom two personalities are striving for supremacy, can regain a state of single mindedness if one of the competing personalities can be obliterated by amnesia. Like schizophrenia, amnesia is also considered an abnormal state, but without passing through both these states many times human intelligence could never have achieved its present level of development.

From time to time in human history there have appeared certain figures who have been at times so overcome with a sense of unity with God and their fellow men that their subsequent lives have been refined and purified by the experience. The author mentions no names, but it is quite clear that he has in mind the mystics, such as Nicolas Cusanus, Teresa de Avila, Blaise Pascal, Jacob Boehme, or Emmanuel Swedenborg. The mental capacity of such people is generally well above the average. The author believes that the future evolution of the human species ought to be, if all goes well, characterized by an increasing porportion of such figures.

Genius is closely akin to insanity. Many insane people are schizophrenics, but so also are many geniuses. The great task confronting medical psychology is to find out why some schizophrenics become insane, and others become geniuses.

The author of this work has propounded something new in psychology. His is a theory with which few will agree at first, but his book is one which fewer still can afford to leave unread.

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Nervousness, Indigestion, and Pain.

By Walter C. Alvarez. Paul B. Hoeber, Inc., New York. $5.00. 9¼ x 6⅛; xii + 488; 1943.

The preface states that

> this is a "different" sort of book, one which deals more with sick, unhappy persons than with their diseases, more with symptoms and their meaning than with disease entities, more with the handling of patients than with the giving of medicines, and more with the puzzling, poorly understood and poorly described abdominal discomforts and indigestions than with the well-known organic diseases such as ulcer, cholecystitis and cancer.... If cases of migraine, nervous breakdown, constitutional inadequacy, pelvic disease, and spondylitis are daily taking up much of his (the physician's) time, why shouldn't a good discussion of these diseases be included in every book designed to help him?

According to the author this book was written to help the teacher in the medical school whose main burden is with teaching and who has not had an opportunity to see a great deal of material outside "the scientific cloister" and "to keep him from forgetting that there is such an organ as the brain, that it has many diseases all its own, and that the symptoms of some of these appear first in the abdomen."

There is no need to mention the author's qualifications for such a book. He is Professor of Medicine at the University of Minnesota and consultant in the Mayo Clinic. He has had, of course, a phenomenal clinical opportunity, and in this book he puts down his actual experiences with patients, the kind of stories they relate, how he goes about getting a story, and what he does about it, in a clear cut but also easy going style which will appeal to the reader. He points out clearly the distressing effects of emotion on the gastro-intestinal tract and to a lesser extent on other parts of the body. He shows how to get a good history and the utmost importance attaching to this procedure, and he makes a very good point of discovering the importance of finding out the patient's real reason for consulting a physician. From his experience he gives numerous practical aids in sizing up the patient, his degree of tension, his suggestibility, his emotional state, and points out several common clinical types—the perfectionistic, the worrier, etc. Every paragraph teems with minute observations.

When he comes, however, to such chapters as the "handling of the nervous patient," "nervous breakdowns," "constitutional inadequacy," "insanity and related troubles" the author gets into topics which are clearly out of his province, and whereas he may subscribe thoroughly to one of the Mayo Clinic's founders' dictum, that every specialist ought to be able to treat a neurosis in his special field—the cardiac specialist the cardiac neurosis, the genito-urinary specialist psychic impotency, etc.—there is very little evidence from the pages of this book that the author has anything more than the most superficial knowledge of this whole issue. A psychiatrist might take issue with the Mayo Clinic's view of this matter and insist that treatment of any neurosis be carried out by a specialist of a special sort and not be left to a cardiologist or genito-urinary specialist or any other sort not adequately trained in psychiatry.

He has discovered that fear is important in the lives of people and that traumatic incidents from the past may be vital in determining a patient's neurotic state and he, in common with most other physicians, has had his successes in explaining these things and through their ventilation accomplishing some good. He throws up his hands in surrender when confronted with the complex, in dealing with the relatively unchangeable environmental circumstances, and dispositional factors, which latter he would lay to constitutional inadequacy and vague hereditary factors. In our present state of knowledge concerning constitutional factors, including heredity, in psychoneurotic and psychotic conditions he goes far beyond the accepted scant information on these subjects, and for his limitations in understanding and treatment pleads a dubious pseudo-scientific basis. It may be accepted that he gains some relief from this sleight-of-hand.

One might take especially vehement objection to the advice to turn a hypochondriacal woman over to a doctor who doesn't know all about her and who will in his ignorance do for what she wants done in the way of treatment; and to the suggestion that it is better for licensed physicians to "treat" the hopeless patient than to allow him to be turned over to the quack who will "fleece" him. What the payment of money to a licensed physician for something which can't in any wise be called treatment should be called is not indicated.

The author states clearly that he is approaching the problem of "nervousness" from the standpoint of the internist, but the result does little credit to internal medicine. He has made a serious mistake in not consulting the best thought in psychiatry and in that collaborative branch of psychiatry with internal medicine which now goes by the term of psychosomatics. A book of this pretension and with such authority would have been better if it had resulted from collaborative effort. It might have lost some of the author's flavor and piquancy, but could not have helped being a sounder scientific document.

EMERGENT MIND AND EDUCATION: *A Study of George H. Mead's Bio-social Behaviorism from an Educational Point of View.*

By Alfred Stafford Clayton. Bureau of Publications, Teachers College, Columbia University, New York. $2.35. 9 x 6; xiii + 179; 1943.

At the turn of the century the psychological world was dominated by the classical psychology of Wundt and James. The theory of evolution had permeated to the remotest recesses of scientific thought but psychology remained unaffected because that discipline was considered to be a branch, not of science, but of philosophy. The psychological principles enumerated by the classical school were quite correct as far as they went, but they had never been integrated into a perfect whole, and as long as the evolutionary principle was disregarded they could not be. James himself defined psychology as the study of mental states as such, the significance of the phrase "as such" being that psychology was concerned only with mental states as they exist, and not as to how they have come into existence. The latter question was quite outside the bounds of the study. With the adoption of comparative and evolutionary methods in psychological investigation the inevitable outcome was the radical behavioristic scheme of Watson. But this was only the second term of a Hegelian triad, of which the psychology of Mead, expounded in the work under discussion, is an attempt to formulate the synthesis.

Mead begins by rejecting the classical system *in toto*, on account of its essential dualism. A dualistic philosophy, he believes, is untenable because it "presupposes the very phenomenon it seeks to explain"—the existence of mind. To the reviewer this attitude seems illogical. Even an unsuccessful explanation presupposes the existence of what is being explained. We may not know objectively exactly what mind is but there can be no doubt that mind exists—we know that subjectively just as Descartes did.

Mead also rejects behaviorism, not because it begins with visceral reflexes but because it ends with them. Here he is on solid ground. We cannot know the minds of sub-human animals except objectively, and we cannot draw comparisons between human and animal psychology unless we confine our study of the human mind to those instruments which are available for the study of the animal mind. This is what behavioristic psychology attempts to do, and what it is justified in attempting. The mistake of the behaviorists is that they neglect and deny the efficacy of introspection as a tool by which knowledge of mind can be acquired subjectively, and in consequence they ignore the sociological factors of mental development.

Although these two systems are essentially antithetical they have one feature in common, in that they both deny that mind has been acquired in the course of human evolution. The classicists begin their philosophy just as Faust did:—In the beginning there was Mind. To them man without mind was unthinkable. On the other hand, the behaviorists, concentrating on the aforesaid visceral reactions, have tended to dispense with mind altogether, having no need for that hypothesis.

Mead's psychology differs from the other two in regarding mind as an emergent. Mind has not existed from the dawn of creation but has somehow emerged during the course of evolution. Incidentally, the theory of emergence originated in Lloyd Morgan's Gifford lectures, but, although the word "emergence" is repeatedly resorted to in the work under discussion, the reviewer does not recall having noticed Morgan's name anywhere in it. (However, it may be there. The book lacks an index and this fact makes a check-up difficult. There is a bibliography, but Morgan's works are not listed in it.)

Mead's theory of emergence is neither a compromise nor a reconciliation. It is merely an effort to avoid the pitfalls that have entrapped the earlier schools. His approach is essentially behavioristic and he calls his system "bio-social behaviorism," but for him behavioristic psychology is only a foundation on which to erect a true science of mind.

Such an attack seems logical. Why then can we not take Mead's psychology straight instead of taking it in Clayton's diluted form? A sentence from the work here under discussion offers a clue. "Some of Mead's expressions concerning the Gestalt movement are too cryptic to be enlightening." As a matter of fact, most of Mead's statements about anything are too cryptic to be enlightening. Without Clayton's able comments it would be very difficult, if not impossible, to get at Mead's meaning. One need only read the excellently expressed summary at the end of each chapter to realize what a large part a capable interpreter can play in the acceptance of a work of this sort.

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STUDIES IN THE LIFE HISTORY OF THE SONG SPARROW. II. *The Behavior of the Song Sparrow and Other Passerines. Transactions of the Linnaean Society of New York. Volume VI.*

By Margaret Morse Nice. Linnaean Society of New York, American Museum of Natural History, New York. $2.75. 9 x 6; viii + 328; 1943 (paper).

Part II of the life history of the song sparrow is a worthy continuation to the now famous Part I. No other passerine bird has been so thoroughly and meticulously studied, with the result that not only has this added much information on the biology of a single species, but it has also provided a stimulus and directive for present and future studies on bird life histories in this country. This is much to be desired since, as the author herself remarks, American ornithologists have been behind their European colleagues in thorough analytical studies in bird behavior. Great dependence is laid to the theories and concepts of Howard, Lorenz, and Tinbergen for the interpretation of the song sparrow behavior. Familiarity with foreign literature enables Mrs. Nice to enrich her own observations with references from many sources, and this fact and the consequent lengthy bibliography make the volume an invaluable contribution on this basis alone.

There are 22 chapters to the volume which, after the introductory chapter to the modern concepts of bird behavior, follow the growth of the nestling from the moment it hatches, through growth and maturity, its activities in fall and winter, its sexual development in spring, the formation of pairs, egg laying and raising of young, closing with a final chapter on innate and learned behavior. Each chapter contains a mass of information that is new and thought-provoking. To be specific, the second chapter is entitled "Development of the young song sparrow." Mrs. Nice recognizes five stages: (1) coordinations mainly concerned with nutrition, (2) first appearance of new motor coordinations, (3) rapid acquisition of new motor coordinations, (4) first week out of the nest, and (5) from flight to independence. Feeding, bathing, escape reactions, social behavior, flight, vocalizations, etc., are traced with the growth of the young bird, the age at appearance and duration of many activities being listed and tabled, including such acts as gaping, yawning, stretching, wiping the bill. Comparisons are made between observations on wild banded birds and hand-raised young. All this in only one chapter, a stage in bird study that is usually glossed over in two or three sentences in other works. Surely the problems raised by the present data will influence future observers for some time to come.

There are three chapters devoted to song. The mass of data, unique in that the author has memorized and learned to recognize the repertoire of individual birds, demonstrate the effect of environmental conditions on bird song, its frequency and purpose. The form, length, timing of the song are typical of the species, but the quality is learned. The awakening song has been traced throughout the year and correlated with critical measurements of light. Three main periods in the starting time relative to the onset of civil twilight are recognized—one coming four minutes after, another coincident with, and a third coming four minutes before. Song in females is discussed in the third chapter where it is pointed out that song in this sex is more prevalent than ordinarily believed.

Each chapter has a summary at the end. There are five appendices, four derived from the notes of the author on the chief vocalizations, dominance, singing, and challenge in hand-raised birds, behavior upon the first arrival of females, and some samples of coition. The fifth appendix has been culled from the literature on cases of injury-feigning.

The book unfortunately suffers from numerous typographical errors and bad type setting. Also Mrs. Nice's terse style of writing leaves the reader in mid-air in several instances. But these adverse criticisms seem insignificant when one considers that here we have a milestone in ornithology which will long remain an excellent guide, text, and reference for all ornithologists, whether they be professional or just observant housewives.

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AWARENESS.

By Eileen J. Garrett. Creative Age Press, New York. $2.50. 8 x 5; xvi+308; 1943.

The reactions of the reviewer to this weird concoction of spiritualism, mumbo-jumbo, faith healings, space floatings, essences, reincarnations, supersensory perceptions, premonitions, apparitions, and general hallucinations were, in order; (1) a slight tingling of the nape of the neck and spine with intermittent hair-raising; (2) extreme hilarity which was diagnosed as contagious insanity, obviously contracted from these pages; and (3) acute depression resulting from a realization of the utter injustice of a world which has sent less noted and less fortunate individuals, suffering from even milder forms of the author's malady, packing off to psychiatric institutions for life.

Apparently there is something of which we lesser mortals (who depend upon our five well-founded senses for our impressions) should be aware. Maybe it is *self*. If so, the author has convinced us that at least she is aware of *self*, and to the extent that the pronouns *I*, *me*, amd *my* are used a total of 450 times in 28 pages (chapter ix) of the text. Many full-length autobiographies have been written with at least 400 less references to the first person singular. The patterns produced by circling these pronouns with blue and red pencils are as convincing as some of those depicted in chapter viii, "Symbolism," or the masterpiece on page 97 couched among the completely uninhibited ramblings of chapter v titled "The breath and color."

If it is not *self* that we should be aware of, then maybe the elusive stuff is hidden somewhere in the following quotations in such subtle terminologies that the reviewer (of supposedly normal intelligence and integrity) was unable to discern it:

> "We have not been adequately taught how to grasp these gossamer filaments of the future which, tomorrow, will be the present; nevertheless the human consciousness is becoming aware of itself and of its affinities throughout the universe. The visions, apparitions, premonitions, and other supersensory manifestations of being, which men and women experience in times of impersonal tension and uplift, are factually true in consciousness—echoes which reach us from the fertile hills of heaven, when we are ourselves somewhat universalized lights reflected from waves on the mysterious sea of the whole of life". P. x.
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> "Later in life I again attended at the death of a friend, a grown young man, a Chinese, who was interested in psychism and was mildly psychic himself. He knew the religious teaching of the East and the West, and he had a reasonable faith in survival, through his intellectual understanding. He had consciously prepared himself for death, as far as possible. And when the time came, at last, I perceived two small clouds emitted from his body—one from the right side of the torso, at the level of the spleen, the other from the top of his head. Like the faint mists I had seen in other cases of death, these moved out into space, weaving within themselves an intricate pattern of vitality". Pp. 150–151.
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> "I was permitted to see the form of G. R. S. Mead. He was not aware that the circumstances of his life had changed. The figure was recognizably he, but it was all drawn together, the back bent far forward, the head drooped low, with the chin resting on the chest and the forehead almost touching the knees; the eyes were completely closed, and the arms, folded across the diaphragm, rested on the thighs. The unconsciousness into which he had entered before dying was not over. Like a person in a delirium, he was still calling for Babs. He was sleeping—not as a human being sleeps, but as an embryo sleeps—a being in process of development from one state of existence into another. It was a form in which vital energies were mysteriously working to some fresh fulfillment. Beside him there were two or three rather wonderful old men belonging to the church. All his life he had been seeking communication with the Gnostic fathers, and they had evidently been waiting to receive him". Pp. 153–154.
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> "I sometimes *saw* (and still do see) through a strange sensitivity in my finger-tips and the nape of my neck, far more clearly than with my eyes. Sound came to me in a current from without, washed my whole body like a wave, and vibrated in the bony structure of my person, so that I *heard* in my feet and in my knees. And I still hear with my feet and my fingers". P. 207.

For an evening of dubious, though rare, entertainment at the expense of a personality which at times has apparently reached the millenium of derangement, this book is heartily recommended.

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PHYSIQUE, PERSONALITY AND SCHOLARSHIP. *A Co-operative Study of School Children. Monographs of the Society for Research in Child Development, Vol. VIII, No. 1. Serial No. 34.*

By R. Nevitt Sanford, Margaret M. Adkins, R. Bretney Miller, Elizabeth A. Cobb, and others. Society for Research in Child Development, National Research Council, Washington, D. C. $2.00. 9 x 6; 705; 1943 (paper).

The authors of this monograph present here the results of a three-year growth study in which almost every conceivable variable of physique, health, family background, social adjustment, personality, and scholarship has been investigated. The problems involved, in constructing a useful summary from the multitudinous data accumulated in such studies, are enormous, and the need which Sanford explicitly recognizes for avoiding preconceptions in breaking such new ground makes the problem of selectivity doubly difficult. Omitting, selecting, simplifying, and rationalizing all offer dangers.

It seems likely, however, that the reader could have been treated better than these authors have treated him.

Physique, Personality, and Scholarship is one of the most unreadable monographs that has come to the attention of this reviewer. Part of the difficulty lies in mechanical factors. The book is printed in mimeotype, has been badly proofread (it even contains a misspelling of one of the authors' names), and one finds no evidence of attention to literary style. But the difficulty goes much deeper. Sanford writes in his summary that his group not only bit off more than it could chew, but that it "included things that were better rejected, things indigestible and things too poor in vitamins." No one can censure the researchers for failing to know in advance what leads would prove profitable, but deciding to stuff their readers with the unprofitable and indigestible, after it has been identified, is surely misguided. It has resulted here in smothering a large number of interesting observations and discoveries under an avalanche of graphs, calculations, correlation coefficients, and special classifications that are, for the most part, of little value.

On the positive side, Sanford and his colleagues must be credited with a useful and thorough application of Murray's Thematic Apperception Test. Their studies have clearly advanced the usefulness of this tool, though it must be admitted that some readers will still boggle at the apparent lack of objectivity in certain aspects of the method. The authors use Murray's system of needs and press (the latter term being gratuitously and objectionably given the same spelling in both singular and plural) and show that the system has sufficient usefulness to repay its careful study.

For the rest, time alone can tell what value this monograph has as a reference work. The reviewer suspects that it will suffer from the same deficiencies which have been mentioned, but psychologists may welcome the thorough survey, by definitions and examples, of Murray's *needs*. One may hope, moreover, that certain hypothetical syndromes, relating these needs to each other and to intellectual variables will stimulate research.

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Principles of Systematic Psychology.

By Coleman R. Griffith. University of Illinois Press, Urbana. $4.50. 10 x 6⅝; xv + 718; 1943.

Here is a book that will prove useful for many years to come, whenever there are graduate students attempting to orient themselves with respect to the classic, theoretical, and methodological issues of psychology. Griffith is a voracious reader who has apparently been able to digest an astonishing amount of philosophic and scientific thought on problems concerning definition and method in the several sciences.

Perennial problems usually have perennial answers, and it is difficult, in the areas discussed by Griffith, to contribute much that is new. As a consequence, *Principles of Systematic Psychology*, for all its encyclopaedic virtue, may seem dusty dry and profitless to those concerned with limited but immediately exciting researches. Today's investigations, on the other hand, reflect yesterday's concern with method, and the most stubborn empiricist must pause occasionally to consider the place of his discoveries in psychology and in the whole structure of science.

For the most part, the stories are old, but Griffith has done us a service in bringing so many controversies up to date and organizing them into the general pattern of contemporary behavioristic views. Such a task would have been impractical had the author attempted to write a history of these problems, and his work will never serve as a reference book. Space limitations preclude a thorough rehearsal of each contribution to psychological theory. But those who want a little history and a clear presentation of the logical and scientific issues facing psychologists will read this volume with profit. Philosophers, philosophically minded social scientists, and, to reiterate, graduate students in psychology will be most grateful for its merits.

The defects of *Principles of Systematic Psychology* are mainly technical. The University of Illinois Press has given the book a handsome but unwieldy format; the seven hundred odd pages could have been produced in a much more compact volume with no sacrifice in legibility. The system of reference followed in the text is inconsistent and confusing; certain sources are indicated simply by a number that refers to the bibliography while others involve the reader in a detour through a footnote before he can arrive at the same information. In the early general discussion, the text is cluttered with far too many references which are of only oblique relevance. The author's style is colorless and his reasoning frequently plodding; the reviewer occasionally lost patience with the amount of effort spent on philosophical and semantic trivia.

In sum, this book has a limited usefulness and a narrow appeal, but it is an honest job of workmanship and its real virtues should be lasting.

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Effect of Added Thiamine on Learning. *Columbia University Contributions to Education, Nunber 877.*

By Ruth Flinn Harrell. Columbia University, New York. $1.75. 9 x 6; 55; 1943.

In this well planned and carefully performed investigation, the author has gathered a significant body of data in support of the thesis that the process of "learning is so related to the nutrition of the body that an increase in learning tends to follow increase in thiamine (vitamin B_1) intake." Several isolated cases reported in the literature have shown that yeast supplemented to an otherwise normal diet tended to stimulate learning in man as well as in various experimental animals.

To test her thesis quantitatively, the author enlisted the cooperation of the Presbyterian Orphan's Home in Lynchburg, Virginia, where she was able to proceed with the match-pair method of investigation among human subjects of school age. Some 37 pairs of children were matched according to a rigid series of physical and psychological measurements. For a period of six weeks, one group was given 2 mg. of thiamine daily to supplement their regular diet (estimated to contain a daily average of 0.9 mg.) while the other group was given a control pill similar in appearance to the thiamine tablet taken by the former group, but containing no thiamine. During the six-weeks period of thiamine feeding, the two groups were given a series of 18 practice tests involving a variety of mental and motor responses. The tests were repeated nine times during the period, and the individual scores were recorded.

The combined scores for each test showed that the thiamine-fed group displayed a marked superiority in the rate of learning over the control group. The advancement of the experimental group was calculated to be 27 per cent greater than that for the control group for all the tests.

The inference is drawn that for maximum learning performances, the human body needs an ample daily supply of thiamine.

DEVELOPMENT IN ADOLESCENCE. *Approaches to the Study of the Individual.*

By Harold E. Jones assisted by the Staff of the Adolescent Growth Study Institute of Child Welfare, University of California. D. Appleton-Century Company, New York and London. $2.00. 8 x 5¼; xvii + 166; 1943.

During the past decade, a number of longitudinal studies of physical and mental growth have been undertaken. Today we are beginning to reap the harvest of several long years of measurement and remeasurement for scores and even hundreds of children of school age. One of the most ambitious of such projects has been the Adolescent Growth Study of the Institute of Child Welfare at the University of California. Its director, Harold E. Jones, now publishes a portion of the findings of that study.

The present publication is no substitute for a complete tabulation of the records of the study, nor is it intended as such. Jones has here brought together, under a single authorship, the results of many interdependent investigations, and he has chosen to present the story of one child's growth rather than to attempt to portray the development of two hundred.

John Sanders is not a fictitious representation of the norms of the California study. He is a real child chosen for presentation here because his case seemed to offer special advantages in epitomizing the methods of the study on the one hand and the forces operating on the developing adolescent on the other. John's story is presented against the perspective of the group as a whole, so that the reader has constantly before him the averages, ranges, and general trends of health and physique, of attitudes and interests, of abilities, social adjustment, and personality.

What is lacking, of course, is a careful treatment of individual deviants from the norms in each category and an analysis of the causes of their deviation. But such a program would have involved a much longer and a much less coherent work. We may hope that Jones and his colleagues will let us have the further data in time. Meanwhile, they are to be commended for having provided an unusually stimulating and instructive little book summarizing what might have been extraordinarily unwieldy statistics. This book should be extremely useful to teachers of courses on the psychology of adolescence.

COMPLEXITY OF MENTAL PROCESSES IN SCIENCE TESTING.

By Frederick T. Howard. Teachers College Bureau of Publications, Columbia University, New York. $1.75. 9 x 5⅞; 54; 1943.

The present investigation was undertaken in an effort to determine the relationship between the mental processes involved in recalling simple factual material, and those required for performing the more complex tasks associated with problem solving.

The data for the study were collected from regular testing programs in six representative American colleges and universities. The tests studied were The American Council Psychological Examination which is commonly given college freshmen, and The Cooperative General Science Test which has been extensively used at the end of the college sophomore year.

The quantitative aspects of the study are analyzed statistically, and discussed in the light of such analysis. Significant among the findings is that, in spite of popular belief to the contrary, the more complex test problems are neither more nor less valid as measures of mental ability, than the simple, specific-item tests. Also, these data have shown somewhat conclusively that the ability to use and organize facts (in problem solving) is essentially the same as that required for recalling specific facts (remembering).

A number of pertinent recommendations for further research in the field have been listed. A bibliography of 26 titles and an appendix of sample test materials conclude the volume.

PHYSIOLOGICAL PSYCHOLOGY.

By Clifford T. Morgan. McGraw-Hill Book Company, New York. $4.00. 9 x 6; xii + 623; 1943.

Here is an imposing and excellent treatise on all the experimental physiological approaches to the problems of modern psychology. All such texts leave one wondering where physiology leaves off and psychology begins, but this doubt resides in the very nature of the material, not in the presentation of the material. The book is appropriately dedicated to Lashley and Richter, who have pioneered important methods in experimental psychology which have led to very important results. There are twenty-six chapters covering all aspects of the material, and the book is thoroughly buttressed by numerous references to the literature, both with footnotes to each chapter and with an extensive bibliography. In any such text it would be unlikely that the reader would not find flaws with some special topic. To give all of the arguments for and against any special procedure or its results would inevitably lead to an all too bulky volume. One may conclude, for example, that this consideration is responsible for the bland treatment of the lobotomy question.

The organization of the material, its extensiveness, and its insight into correlated problems of physiology and psychology stamp the book as an important document in the field.

* * *

PAIN: *Proceedings of the Association for Research in Nervous and Mental Disease. Volume XXIII.*

Edited by Harold G. Wolff, Herbert S. Gasser, and Joseph C. Hinsey. Williams and Wilkins Company. Baltimore. $7.50. 9 x 6; xii + 460; 1943.

This is a monumental treatise on every aspect of pain, containing the recent anatomical, experimental, physiological and clinical studies and interpretations. There are thirty-seven contributors to thirty-two chapters. It would be hard to pick out the outstanding item, and such a choice would only reflect the reviewer's predilections. Perhaps one might point to the studies of Harold G. Wolff and his collaborators on the headache mechanisms and pain arising from the stomach and mechanisms underlying gastric symptoms as unusually well developed topics. Likewise Wolff and Goodell's final study on "the relation of attitude and suggestion to the perception of and reaction to pain" is most important. The authors describe somewhere the method for determining pain threshold and finally the effect of emotional states on the apparent threshold.

The book is beautifully done with numerous charts and references, and as usual the discussion of each topic in its appropriate place. This volume will stand up well in comparison with its predecessors from the Association For Research in Nervous and Mental Disease.

HYPNOTISM.

By G. H. Estabrooks. E. P. Dutton and Company, New York. $2.50. 8 x 5½; 249; 1943.

This is another book on hypnotism, one may suppose published at this time because of the resurgence of interest in the subject in the last few years. It is a good enough account of the history and practice of hypnotism, although in the historical review it is strange not to see mentioned the name of Forel whose little treatise on hypnotism is a classic. The author again poses the oft asked question as to whether, under hypnotism, crime would be performed at command. His own view is that it probably would, and he makes the point that no one has ever tested this theory to the limit. He hints rather darkly that hypnosis is being used during the present war in the Secret Service and indicates some ways in which it might be employed. Whether his caginess about this is actually in the interest of keeping military secrets secret, or whether he is going off into the practicing hypnotist's wish fulfillment dream, no one knows. I find it hard to believe that the Secret Service has gone in for hypnotism as one of its standard methods. This part of the treatise sounds like the basis of a movie plot to supplant the "31 Steps."

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CONTEMPORARY PSYCHOPATHOLOGY. *A Source Book.*

Edited by Silvan S. Tomkins. With an Introduction by Henry A. Murray. Harvard University Press, Cambridge. $5.00. 9¼ x 5⅞; xiv + 600; 1943.

In this volume are gathered together forty-five articles from recent current literature dealing with outstanding problems in psychopathology. They are grouped under four headings: Mental disease in childhood; Psychoneuroses and psychosomatic medicine; the Schizophrenic psychoses; and Experimental psychopathology. An excellent choice of material has been made for each section, and there is not a little advantage to be had in the presentation, within the covers of one book, of such widely scattered material as these numerous articles. The book is deficient in only one respect. It has practically nothing to say about treatment, but this was purposeful, and within the limits set by the editor it is hard to see how a better job could have been done. The material is essentially research material, both from the laboratory experimental standpoint and from the clinical standpoint. Thorough digestion of the results of these accounts will certainly leave the reader abreast of the most advanced knowledge in these fields.

* * *

THE STRUCTURE OF MORALE.

By J. T. MacCurdy. Cambridge University Press, Cambridge: The Macmillan Company, New York. $2.00. 7⅜ x 5; vi + 224; 1943.

This is an excellent book, a compendium of lectures which the author has given to various groups during the war. It is full of observations on the factors promoting or retarding morale, full of illustrations from actual experience. Especially interesting are the observations on the different bases underlying British, German, Russian, Japanese, and Chinese morale. As might be expected, he has a lot of good things to say for the British. The fact that the British have actually lived up to what he says about them removes his observations from the sphere of snobbishness. The style is excellent. His auditors must have enjoyed a real treat. It is an excellent book.

* * *

THE SUBSTANCE OF MENTAL HEALTH.

By George H. Preston. Farrar and Rinehart, New York. $1.75. 7¼ x 4⅞; 147; 1943.

In Preston's first book he demonstrated a remarkable capacity for telling the essence of psychiatry in language which was accurate and understandable by the layman. His second book does the same thing for mental health. In short it is a very fine statement in simple terms of generally accepted thought in regard to the substance of mental health. The author uses analogy liberally and effectively and shows good common sense and good humor. This is a book which deserves the widest recognition and perusal. Psychiatrists as a body might profit by training themselves in Preston's capacity to tell truths simply.

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

TIME: THE REFRESHING RIVER. *Essays and Addresses, 1932–1942.*

By Joseph Needham. The Macmillan Company, New York. $3.75. 8¼ x 5⅜; 280; 1943.

This book is destined to be misunderstood. It is an attempt to unite Communism and Christianity, not by reconciling them but by consolidating them. What the author has to say about Communism is likely to irk the orthodox Christian, and what he has to say about Christianity will certainly antagonize the communist. Needham is not a member of the clergy and so runs no risk of a heresy trial which was the fate of Bishop William Montgomery Brown who essayed the same task a generation ago. If the average man could be inveigled into reading this book (which is doubtful) he would probably put it down unfinished, exclaiming in the words of Porcius Festus, "Paul, thou art beside thyself, much learning hath made thee mad."

The feature of the work most likely to impress the reader with the author's erudition is his use of numerous quotations from Chinese philosophical writings, expressed in native characters. The ability to read Chinese classics in the original should not seem surprising in one who translates Polish literature in his spare time and studies Aztec philology as a relaxation, but it is surprising that he always resorts to the Latinized form of the name of the greatest of all Chinese philosophers, Kung Fu-tse.

The eleven essays of which the book consists are independent in that each is complete in itself, but they are united into a single whole by a common underlying philosophy. Politically the author is a radical with much sympathy for both Socialism and Communism. Yet the sources of his data on these subjects seem somewhat circumscribed. Karl Marx is mentioned in nearly every essay, but all the author can tell us about Robert Owen is that he was influenced by John Bellers. There is much about Frederick Engels, the theorist, but nothing about George Rapp, the practical man of action whose communistic settlement was much more than an experiment—it endured for more than a century. There is a lengthy discussion of Communism in seventeenth century England (incidentally, this is a scholarly contribution to a little known phase of history) but no mention of its development in nineteenth century America by the Oneida colony, the Amana society, the Hütterian brotherhood, or the Harmonists.

The author takes great delight in the literary exhumation of those with whom history has dealt unkindly, such for instance as Henry Drummond. The latter was really one of the great philosophers of his day, despite the somewhat condescending glances which the current intelligentsia bestow upon him. It is refreshing to find a modern writer capable of enthusiasm over him. Yet in Needham's enumeration of the writers to whom Drummond is indebted we find the names of Spencer, Marx, Engels, and Hegel, with no mention at all of the one philosopher who probably influenced him more than all the others together—John Fiske. And the name of Joseph LeConte, whose synthesis of religious and scientific thought was probably more nearly perfect than that of any other writer before or since, is conspicuous by its absence.

Another forgotten worthy to whom Needham renders belated justice is Archbishop Laud. It now appears that this dignitary was by no means the villain that he is commonly portrayed to be, but was really the champion of the common people whom he protected from persecution. It is interesting to recall that a similar appraisal of Laud was made by Irwin St. John Tucker, whose *The Geography of the Gods* resembles the present work, not only in being an attempted synthesis of Communism and Christianity, but also in having been produced during a war and being printed on the cheapest kind of paper available. But whereas Tucker's work was intended for circulation among the laboring classes and was printed on a news' press to keep expenses down and so permit of wider circulation, Needham's is essentially esoteric in its appeal, and costs about twenty times as much. Both are good, and both are needed to prepare the way for the new social system which must arise when hostilities cease.

Scientific Method and the Conditions of Social Intelligence.

By Helen Louise Whiteway. Introduction by R. Bruce Raup. Trade Printers and Publishers, Ltd., St. John's, Newfoundland. $2.00. 7⅝ x 5¼; x + 188; 1943.

One of the effects of Lloyd Morgan's doctrine of emergence has been a renascence of the philosophic theory of vitalism. But the name still seems to be under a taboo. We seem to have an instinctive fear of the name but not of the thing.

The alternative mechanistic theory holds that all biological phenomena are explicable in terms of physics and chemistry, while the vitalists maintain that the phenomena of biology are of a different order from those of inanimate nature.

The present author, although she does not call herself a vitalist, not only accepts the vitalistic outlook but goes it one better by claiming that sociological phenomena are inexplicable in purely biological terms. This is merely a matter of definition of biology, and in these days of specialization the students of morphology and physiology may even be glad to have the responsibility for sociological research lifted from their shoulders. For purely empirical reasons the emancipation of sociology may be desirable, but it is doubtful whether many minds will accept the rational considerations on which the author arrives at her decision.

The author maintains that the difference between sociology and the restricted biological sciences is not so much one of field, but of method. The method of biology is no longer applicable, she believes, when we enter the domain of sociology. This is a dangerous belief, for the scientific method is a jealous god who permits no short cuts along the tripartite path of the verification of facts, the classification of facts, and the drawing of inferences from facts. It is impossible for the scientifically trained mind to conceive of any royal road to learning.

The author gets around this difficulty by limiting science to the conclusions which may be drawn from the mensuration of quantitative phenomena. As an illustration of the way in which knowledge of qualitative phenomena may be acquired without recourse to scientific method she refers to the field of aesthetics.

The question as to how far aesthetics is amenable to scientific treatment is a large one, and to discuss it here in detail would involve too wide a digression from the book under discussion, but it is not inappropriate to point out here that Karl Pearson (who was probably the greatest philosopher of science in recent years, as well as a poet and a dramatist) seems to have entertained some very hazy notions about aesthetics. He maintained that the scientific method was the only approach to truth, that there were no limits to what the human mind could achieve, but that aesthetics was outside the domain of science. Thus the appeal to aesthetics is fraught with difficulties.

The author also accepts a fundamentalist interpretation of Heisenberg's principle of uncertainty. The generally accepted interpretation of this dictum is that the observation of either the position or the velocity of the particle alters either its position or its velocity in such a way that although either one of these may be accurately observed at any time it is impossible to observe both simultaneously. The author's interpretation, if the reviewer does not misunderstand her, is that the relation between the position and the velocity of a particle involves an independent parameter that is uncaused and behaves capriciously, so that there is a degree of freedom in inanimate nature within narrow limits.

The reviewer has great sympathy with the author's effort to free sociology from the trammels of physicochemical mechanism, but fears that in so doing she has risked the impalement of herself on the opposite horn of the dilemma—the acceptance of a chaotic universe.

A Treasury of Science.

Edited by Harlow Shapley, Samuel Rapport and Helen Wright, with an Introduction by Harlow Shapley. Harper and Brothers, New York. $3.95. 8½ x 5⅜; xi + 716; 1943.

This book has been called a symposium of science, but it is far from being that. Rather it is a miscellany —one can readily visualize the editor sitting down to work with a pair of scissors and a pot of paste. Some of its chapters are translations of original classics of science, such as Galileo's proof of terrestrial motion or Copernicus' discussion of the heliocentrism of the solar system; some are twice-told tales that gain greatly in literary value on repetition, such as those from the pen of Paul deKruif and of Eric T. Bell. Owing to the superior literary ability of these writers we can learn more about Antony Leeuwenhoeck and Evariste Galois than we could if these celebrities had left us their own autobiographies. Finally there are a few articles whose significance is exclusively literary, and in which science plays but a small and incidental part, such as the contributions by Dallas Lore Sharp and Fairfax Downey.

One very surprising chapter is Benjamin Franklin's discussion of daylight saving. Can this be the same person who once wrote under the pseudonym of Poor Richard,

> "Early to bed and early to rise . . ."

who now tells us that he goes to bed between three and four hours after midnight, that he has never seen any sign of sunshine before noon, and that he was astonished to observe that the sun begins to shine as soon as it rises? Yes, it must be, for he tells us that he loves economy exceedingly, and to prove it computes that the city of Paris might save annually ninety-six millions and seventy-five thousands *livres tournois*' worth of candles merely by rising six hours earlier.

The story that Victor Heiser has to tell us about leprosy in the Philippines is an inspiring one—but it is not possible to do justice to it in a few words. One should read the chapter in its entirety—or better still, the entire book from which it is quoted.

In a work of this sort it is quite a surprise to find the *Popul Vuh*. This work is of no great interest in itself, but it is important because it is one of the few pre-Columbian works that escaped immolation on the altar of Archbishop Landa. What would we not give today for a tenth of the documents that went up in smoke at the tyrannical hands of the conquistadores!

Among the other well-known authors represented in this collection may be mentioned Kirtley Mather, Edward Jenner, Vilhjalmar Stefansson, Arthur Keith, and Eve Curie—to select but a few at random. The closing chapter is a highly imaginative piece of writing, by J. B. S. Haldane, called "The Last Judgment." It is a description of the extinction of the human species on the earth as witnessed by an inhabitant of Venus.

Scientific Illustration.

By John L. Ridgway. Stanford University Press, Stanford; Oxford University Press, London. $4.00. 10 x 6¾; xiv + 173 + 23 plates; 1938.

The real advantage of illustrations is, of course, well known to all scientific writers and readers. Illustrations lend interest, aid in the elucidation of facts, save valuable time in writing descriptive matter, and relieve the reader of much mental effort by giving him a clearer and easier conception of what he reads. As a matter of fact, it is almost impossible to describe adequately the form and details of structure of many organisms without resorting to some kind of illustrative drawing. Yet, the lack of effectiveness and ofttimes the complete inadequacy of the illustrations of many of the scientific textbooks, journals, etc. is too often apparent. Many a good scientific presentation has lost much of its deserved effectiveness because of poorly planned and poorly executed illustrative material.

The author, a scientific illustrator and artist of considerable ability and wide experience, points out that the advance in the use of illustration in the literature of science has by no means kept pace with the tremendous advance made in recent years in the use of illustration in the many books and magazines of popular interest and in commercial advertising. The design of the present volume is, therefore, an attempt on his part to give practical aid in the essentials of scientific book illustration to both the writer and the artist whom he may employ.

To obtain good original illustrations the following essentials may be listed: (1) The material selected should be pertinent and expressive; (2) The kind of publication and the size of the illustrations should be clearly kept in mind. For example, preliminary reports warrant only simple and inexpensive illustrations while extensive treatments of a subject deserve more elaborate illustration. As a general rule every sketch should be made larger than publication size, preferably twice publication size, whether it is a simple diagram or a base map; (3) The kind of reproduction—line cut, half-tone, lithograph, etc.—should be carefully considered with regard to the type of article or report and always with regard for the reproduction of essential details; (4) Each original should be complete and so made that it can be understood and followed without question. (Draftsmen and editors should not be expected to supply missing links!)

The book itself is somewhat of a model in illustration containing as it does twenty-two plates and twenty-three text figures, all very well executed. As a whole it should prove useful to students of science, particularly graduate students, and to any one engaged in the preparation of manuscripts that require illustrations.

The Nature of Explanation.

By K. J. W. Craik. Cambridge at the University Press. $1.50. 7⅜ x 5⅞; 123; 1943.

It is difficult to appraise this book. Its subject matter borders on relativity physics, quantum mechanics, semantics, and ontology and to the profundity of thought of the first two it adds the esotericity of language of the last two, with a result that is far beyond the ability of the ordinary laboratory biologist to comprehend. Only on the final page is the mist dissipated and the mountain peaks on the other side of the valley allowed to come into view.

On this page the entire book is summarized in a comparison of the human intellect with a computing machine. When the former makes use of past observations to forecast the future its action is like that of the latter. This theory will offend neither the mechanists not the vitalists, for even the most perfect machine is dependent upon the services of an engineer.

The author claims that his theory is capable of being tested by experiment. If this should prove to be the case it will probably be the first time that any theory of the relation between matter and spirit has been so tested. The incapacity of other theories to afford experimental investigation is not a defect of the experimental method but of philosophic thought. It is highly desirable that this attempt be made.

The writer of the blurb on the cover seems to have experienced the same difficulty in digesting this work as the reviewer, for he snatches at that final page like the proverbial drowning man after a straw.

The reviewer hopes that he may be pardoned for recounting here an anecdote which the perusal of this book has called to his mind. It seems that an amateur composer, whose name has remained unknown, once submitted a manuscript to Rossini for criticism, with the explanation that it was a funeral march in memory of Meyerbeer. Rossini's brief and terse comment was "It would have been better if you had died and let Meyerbeer write the funeral march." Similarly, the reviewer feels that if the author of this book had written the blurb, and if the author of the blurb had written the book, the latter would have gained in readability, even though it might not have been such a weighty contribution to philosophic thought.

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ENCYCLOPEDIA OF SUBSTITUTES AND SYNTHETICS.

Edited by Morris D. Schoengold. Philosophical Library, New York. $10.00. 9 x 6; 382; 1943.

The present war has focused attention upon the fact that this country is not as self-sufficient in its raw material requirements as many of us believed. As is well known, many vital materials are practically impossible to obtain. This is so because of the fact that many of them are insufficiently stocked for the use of both our armed forces and civilian economy. An attempt has been made in this book to indicate just what may be used in place of these hard-to-get materials. The editor felt, however, that a mere listing of these substitutes would be insufficient. He has consequently gone further and has compiled an encyclopedia in which has been listed the materials themselves, and, in addition, there is presented some of the chemical and physical properties of the materials and products. In this way it is hoped that further uses may be found for many of the items listed. The book discusses substitutes of interest to all branches of industry, manufacture and pharmaceutics. It also includes comprehensive explanations of plastics and other synthetics which for years have been replacing many of the commonly known applications of metal. In numerous instances such replacements have often proved to be superior to the original material. The subject matter of this type of book obviously changes very rapidly. Apparently every attempt has been made in the present instance to include the most recent developments. The book should serve as an excellent starting point in the hunt for replacement materials. All of the synthetics and substitutes are listed in alphabetical order, making them easy to find. There is an index of trade names and a subject index.

The encyclopedia, reported to be the first of its kind in any language, should prove to be of considerable usefulness to industrial and laboratory chemists and to all others who are in search of new and improved materials. The production manager should find the book as simple as it is practical.

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OUR LIVING WORLD.

By Carroll Lane Fenton. Doubleday, Doran and Company, New York. $4.50. 9 x 6; vi + 312; 1943.

The difficult task of presenting a scientifically sound and modern understanding of the origin and evolution, as well as the physical attributes and every-day economies of the world of living things, in a non-technical manner for popular consumption, has been brilliantly accomplished by the author of this volume.

The first 7 chapters cover the genesis and evolution of life on the earth, and the relationships among modern plants and animals, as well as their affinities for numerous pre-historic relatives. Chapters 8 to 16 deal with the physiological processes of plants and animals as related to their growth, development, adaptability, and reproduction. Heredity as related to evolution and general human progress is discussed in chapters 17 to 20. The ecology of plants and animals, and the foundations of evolution are covered in the last 8 chapters of the volume.

The biological concepts herein discussed are not only thoroughly accurate, but are presented in a superbly stimulating manner. Many well-chosen illustrations enhance the value of the volume for general reading. The complete index will contribute to the use of the work for reference purposes.

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ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION *Showing the Operations, Expenditures, and Condition of the Institution for the Year Ended June 30, 1942. Publication 3705.*

Smithsonian Institution. U. S. Government Printing Office, Washington. $1.50. 9 x 5¾; xiii + 421; 1943.

Although this volume is shorter than the previous reports from this Institution, reviewed in these columns in the past several years, it follows the high standards set in the earlier reports. As usual, the summaries of the year's activities of the various branches and committees of the Institution are followed by the General Appendix, which contains a number of accounts of scientific investigations and discoveries made by collaborators of the Institution. Those that should be of special interest to the biologist include: "Is there life on the other worlds" by Sir James Jeans; "Ultraviolet light as a sanitary aid" by Louis Gershenfeld; "Chemical properties of viruses" by W. M. Stanley; "The nutritional requirements of man" by C. A. Elvehjem; "Past and present status of the marine mammals of South America and the West Indies" by Remington Kellogg; "The return of the musk ox" by Stanley P. Young; "Insect enemies of our cereal crops" by Remington Kellogg; "The geographical aspects of malaria" by Sir Malcolm Watson; "The bromeliads of Brazil" by Mulford B. Foster; and "Canada's Indian problems" by Diamond Jenness.

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The Wisconsin Pine Lands of Cornell University. *A Study in Land Policy and Absentee Ownership.*

By Paul Wallace Gates. Cornell University Press, Ithaca. $3.50. 9 x 6; vii + 265; 1943.

This detailed and exhaustive study, the result of years of painstaking research through records and literature, discusses the ramifications and entanglements resulting from Ezra Cornell's acquisition of pine lands in Wisconsin as an investment for the support of the university he had founded. Although primarily written from the point of view of historical, economic, and social science, the book brings out significant aspects of the stormy period of exploitation by absentee ownership of valuable national resources. The legal battles, the ill will of the inhabitants of the region, the attempts of grasping and unscrupulous men to gain control, the loyal integrity of Henry Sage and others, are here covered with scientific impersonality.

However, in spite of failures and misfortunes, Cornell, through superb management, was able to preserve the value of the pinery counties so that the undertaking proved to be one of the outstandingly successful land speculations in the history of this country.

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The World Coffee Economy *with Special Reference to Control Schemes.*

By V. D. Wickizer. Food Research Institute, Stanford University. $3.00. 9 x 6; x + 258; 1943.

This volume will be of particular value to those agencies which are charged with the study of commodity problems on an international basis. The Food Research Institute has made a careful and thorough study of the coffee problem from all possible angles. Aside from those sections which have to do with the statistics and economics of coffee production, international agreements, etc., all of which are of much general interest, there is included a great deal of information of a specialized nature on this widely used product which will be of interest to the biologist. The volume is thoroughly documented and carefully indexed. In an appendix is set forth the Inter-American Coffee Agreement. Many statistical tables are included in the report.

The importance of The Food Research Institute, which came into being after the First World War, through the far-sighted wisdom of Herbert Hoover, is indicated by its growing list of publications concerning food products of the world.

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Taxidermy.

By Leon L. Pray. The Macmillan Company, New York. $1.49. 8 x 5⅜; viii + 91; 1943.

Sportsmen who desire to perpetuate their trophies and others interested in the art of taxidermy for other reasons will find this little guide useful. The preparation and mounting of a deer head, a fish, a bird, a wildcat, a small mammal (squirrel) and lastly, a tortoise, horned toad, and crayfish, are described both in text and figures. The first chapter lists the essential tools and materials necessary to do taxidermy, and a much longer tabulation for those who take the work seriously. There are also brief notes on papier-maché, pastes, and moth-proofing solutions. Although profusely illustrated, the text is so condensed that the beginner will have to rely on his own good judgment to fill in some of the details not mentioned. The writer favors borax to the arsenic method of preservation and offers many other useful hints and ideas.

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Against This Rock.

By Louis Zara. Creative Age Press, Inc., New York. $2.75. 7¾ x 5½; 635; 1943.

Louis Zara has written a vivid account of the dramatic life of Charles V, Hapsburg ruler of the Holy Roman Empire, and set it against the background of sixteenth century Europe—the enigmatic period of the Reformation. The book is, on the whole, accurate in detail and is written in an intensely interesting fashion.